Environmentally Sensitive Maintenance
for
Dirt and Gravel Roads

Chapter 5: Environmentally Sensitive Maintenance Practices: Roads and Road Drainage

5.1 Introduction

Like when building a good road, we started with a sound foundation. We described the pollution problem from a historical perspective, discussed traditional road maintenance practices, and defined our goals and objectives. We then discussed geology, rocks, and soils as raw materials (giving you what you have to work with) for road maintenance, and continued building on that foundation with road maintenance and natural systems basics. Now, combining and using all that information, we are ready to examine good, sound, specific "Environmentally Sensitive Maintenance Practices" that will benefit both the road and the environment.

Once adopted, these practices will become commonly used tools in your road maintenance toolbox. In some cases, you may already be using the practice we discuss. In others, you may just need to tweak the practice to make it more sensitive to the environment, but still be effective for the road. Some practices may be new, but may fit a need or a particular site.

As with all maintenance and maintenance projects, we need to make that field inspection, evaluate the conditions and decide what needs to be done. The more practices or "tools" available in our toolbox, the better we will be able to perform the required tasks to prevent pollution and prolong the life of the road. Not one tool or practice will solve all your problems, but with a full toolbox, you will be able to select the most appropriate tool or tools for the job.

5.2 Erosion Prevention and Sediment Control

When we talk about erosion and sediment, we should emphasize erosion prevention. If we prevent erosion from happening in the first place, there is no sediment to pollute. Erosion prevention becomes our first line of defense. Look at the badly eroded road in Photo 5-01. Notice the banks on each side of the road. At what elevation do you think the road surface was forty years ago? The road

5-01 Typical entrenched eroded road.

would not have been built at the present elevation. If the road surface was originally at the top of the banks, where did all the material go? This is only one small section of road. We have many miles of forested roads with similar profiles. From this photo, we can see why sedimentation, by volume, is the largest pollutant of our streams. Typically, roads with higher banks on each side cause can be improved by filling the road cross section. This technique, although involving major fill work, will be discussed in Section 5.3.7, along with all its advantages.

5-02 Once erosion takes place, the sediment needs to be addressed.

When erosion does take place, for whatever reasons, then we have to control the resulting sediment. Otherwise, we can end up polluting our streams and have serious problems both for our roads and the environment.

5.2.1 Managing Your Erosion Prevention and Sediment Control Systems. Whether temporary or permanent controls, managing your control systems is important. Periodic inspections of your roads, drainage facilities and work sites allow you to keep an eye on potential problem areas and identify problems when they first start. For example, a vulnerable spot around a culvert is a danger sign. If ignored, it could create major road problems, damage the environment, and escalate costs. The following sections include sound practices that can make your control systems more effective and efficient.

5.2.2 Temporary and Permanent Erosion Prevention and Sediment Control Measures. Road managers have a wide variety of control methods or practices at their disposal to combat erosion and sedimentation. They range from the simple to the complex. In some cases, it may be as simple as widening a ditch or flattening a slope to reduce water velocity.

Erosion prevention and sediment control can be broken into two areas or conditions that we have mentioned before:

Temporary Practices: Practices used before or during construction or maintenance work to prevent and control only for those activities. These include emergency work situations. Some practices serve as either temporary or permanent solutions. Other temporary practices can be used during maintenance and construction activities and become permanent after the work is completed.

Permanent Practices: Practices uses as long-term prevention controls, often requiring little or low maintenance. These practices may be simple or complex in construction and costs.

5.2.3 Basic Temporary Practices. Two of the most common temporary controls are straw bales and filter fabric fence (silt fence). Unfortunately they are also the most improperly used techniques on road construction and maintenance work sites. Although the use of bales has traditionally been a popular method of sediment control from work sites, the fact remains that they are relatively ineffective. **Straw (or hay) bales are not recommended for use.** Bale barriers have more failures than successes and are expensive to install and maintain. The Federal Environmental Protection Agency (EPA) does not recognize bale barriers as an appropriate control method. Since straw bale barriers are still being used in many areas, the most effective installation practices are described below, followed by the recommended commonly used silt fence (fabric filter fence) barrier.

5.2.3.1 Straw Bale Barriers (<u>not recommended by EPA</u>). Straw bales are for temporary use only. Bales should not be used for more than 3 months. They should not be used in concentrated flow conditions. They should only be used for sheet or shallow flows.

5-03 Improper bale installations doomed to fail!

Proper installation is essential as shown in Figure 5-1.

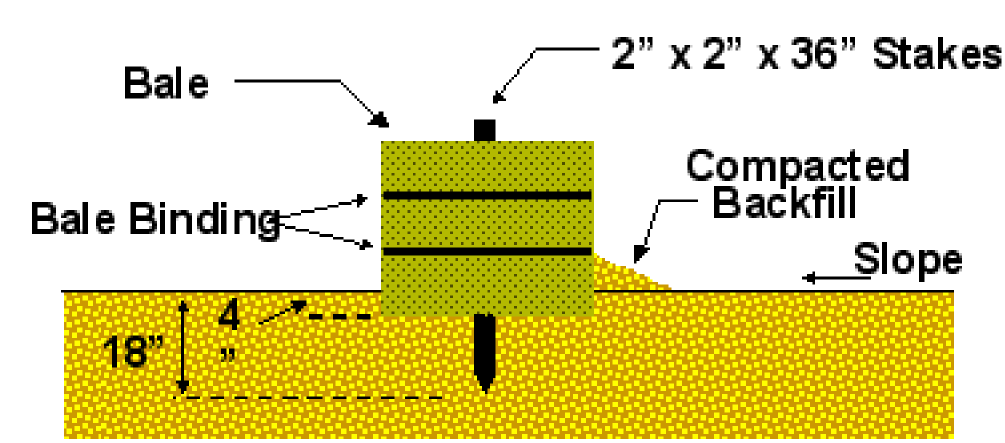


Figure 5-1 Proper Straw Bale Barrier Installation

They should be placed in an excavated area approximately four (4) inches below the ground surface and the excavated soil compacted on the upslope side of the bales. Each bale should be anchored securely by 2 support stakes with straw being wedged between the bales. Notice in the figure that the bale bindings are horizontal, not vertical, where they would be in contact with the ground and susceptible to rot or degradation. Photo 5-04 shows a proper installation immediately prior to a major construction project.

5-04 Proper bale installation prior to start of a major construction project. (Note: Bale barriers not recommended by EPA.)

They need to be inspected at regular intervals and cleaned or replaced as needed. Cleaning should take place when the sediment reaches 1/3 above the ground height of the barrier.

5.2.3.2 Silt Fence Barrier. Silt fence or filter fabric fence is a geosynthetic, or specifically a geotextile fabric, designed for the filtration function needed in sediment control. Again, this fabric is for temporary use only and should not be used for concentrated flow conditions, as can be seen in the photos. Silt fence is normally used at the toe of slopes for sheet sediment flows.

5-05 Improper silt fence installations.

Proper installation is essential, as shown in Figure 5-2. The fence needs to be anchored by digging a small trench and burying the toe of the fabric as shown. Wood or metal stakes need to be place on the downslope side of the fabric to properly support the installation against the load.

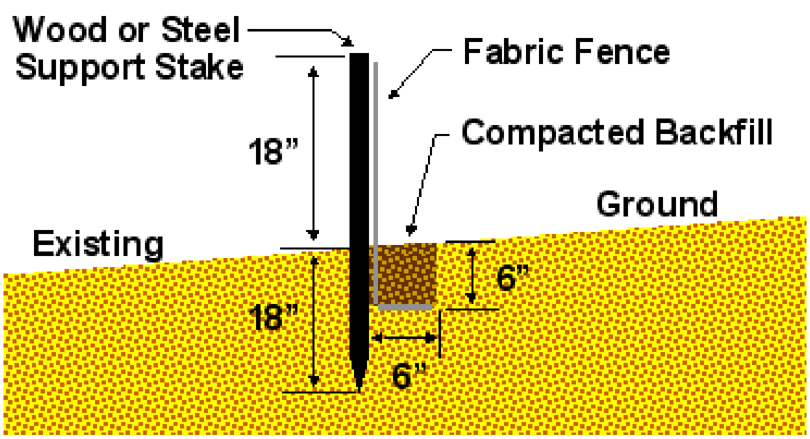


Figure 5-2 Proper Silt Fence Barrier Installation

5-06 This installation will not control much sediment!

Photo 5-06 shows an improper installation with the bottom of the fabric above ground level (this will last a long time but won't control much sediment). Photo 5-07 shows a good installation in a new paved road subdivision that has not been maintained. Although this photo shows the strength of a silt fence barrier, the risk of a system failure is imminent, and the consequences of pollution and cleanup required could be quite substantial. Filter fabric fence should be cleaned when the sediment reaches one-half the height of the barrier.

5-07 Cleaning is required when sediment reaches one-half the height of the fence.

Like straw bales, frequent inspections followed by proper cleaning or repairs are necessary for proper performance. Filter fabric fence is much more effective and has a much longer life than straw bale barriers but still must be installed properly, inspected regularly and properly maintained.

5.3 Environmentally Sensitive Maintenance Practices

Let's turn our attention to more permanent practices that both prolong road life and are good for the environment. Specifically we will look at environmentally sensitive practices involving the road profile, driveways, drainage ditches, culverts, end structures, stream crossings, and bridges. Roadsides and banks will be specifically addressed in Chapter 6.

These practices, as stated before, are mostly simple, practical techniques that can be easily implemented. Local government road crews can perform most of the practices with available equipment resources, incorporating them into their normal routine road maintenance program. Not all practices will apply to any one road or one road system, but having a full toolbox to address any problem encountered lowers overall costs. Many of these practices can be used in combination and will apply to most dirt and gravel roads in general. And many practices are also useful on paved roads.

As we discuss these practices, keep in mind that proper drainage is absolutely essential to prolonging road life and protecting the environment. Drainage means handling flowing water. Greater volume and greater velocity (speed) of that water result in greater erosion and sedimentation. In other words, if we can limit the volume of water and slow it down, we diminish the energy and erosion potential of the flow. Many of the practices to be discussed are based on this "divide and conquer" premise. By limiting the drainage area contributing to the flow, we reduce water volume, thus allowing smaller sized drainage facilities (ditches, pipes, etc.). This reduced area also reduces the flowing water's ability to pick up speed, reducing energy and the likelihood of erosion.

Common practices will be mentioned without elaborate detail but with some explanation of the rationale for inclusion. Other more uncommon practices will include a short description and associated sketches as necessary for clarification. For discussion purposes, the practices are organized into related groups.

5.3.1 Practices Related to Road Profile. In Chapter 3, we discussed the importance of road crown and cross slope, road shoulders, good road materials, and proper road drainage. Following those basic practices will result in a better road and promote a better environment. But beyond those basics, we now introduce several alternate road profile practices.

5.3.1.1 Insloping. "Insloping" of the road can be applied when the road runs along a steep bank. With a steep uphill bank on one side and a steep downhill bank on the other, common practice is to install a normal crown (see Figure 5-3a). This practice concentrates the water volume and flow, causing erosion with the possibility of a severe washout down over the bank and normally into the adjacent stream below. Sometimes a berm dam is installed along the edge of the road at the top of slope. The berm dam can also cause a secondary ditch with poor road drainage and a build-up of water volume and flow that could result again in a severe washout.

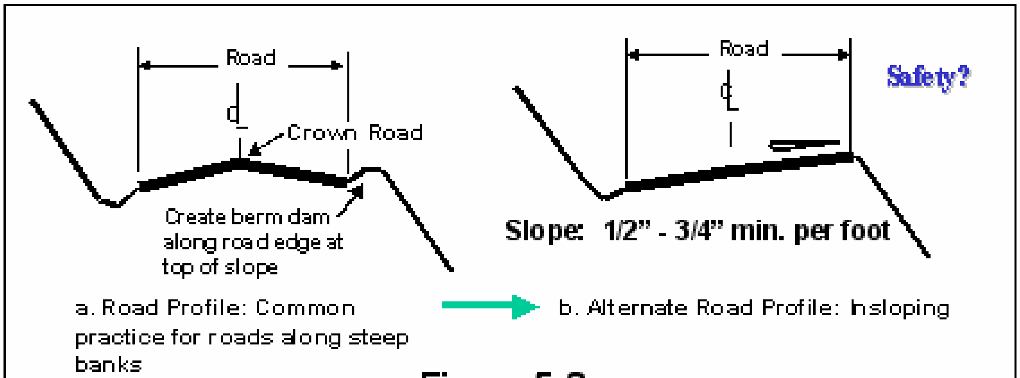


Figure 5-3

Insloping the road using normal cross slopes may take care of this problem (see Figure 5-3b).The entire road is sloped toward the uphill side, eliminating flow over the steep downhill slope and the possible erosion and washout into the stream. The only water reaching this downhill slope will be the rain that falls directly onto the surface. The water draining from the road and the uphill slope still should be collected via a ditch on the uphill side and carried to a cross culvert. The only additional water, however, that is draining into this ditch is from the other half of the roadway surface. This limited additional water volume will not require changes in ditch and culvert sizes. Culverts can be placed strategically with outlet flow protection as needed. The berm on the downhill side can still be built up if desired for safety of vehicles.

5-08 Road candidate for insloping.

Photo 5-08 depicts the typical conditions for insloping. We can prevent water from flowing over the face of the downhill slope by sloping the entire roadway toward the uphill embankment on the left side of the photo. We need to collect this water into a side ditch and to a cross pipe to outlet away from the road. In this photo, we can see how the stream meanders close to and then away from the road. The cross pipes can be strategically located where the vegetative grass strips are the widest to filter out any potential sediment prior to entering the stream. At this particular site, a cross pipe can be installed further down the road where its outlet would be at a flat rock outcrop. This rock configuration will spread the flow, acting as an energy dissipater prior to a grass filtering strip and the stream.

Vehicular safety has to be considered in this approach. Keeping the cross slope at a minimum and considering low traffic volumes, we can still maintain a berm dam on the downhill side for extra safety perception since everything is draining away from that side.

5.3.1.2 Outsloping. "Outsloping" of the road can be applied when the road crosses a **gentle sloping terrain**. Common practice is to install a crown with side ditches. This configuration (see Figure 5-4a) creates a dam and concentrates the overland sheet flow with possible erosion of ditches and ditch outlets. This profile also requires cross pipes to outlet the uphill side ditch with the potential clogging and flooding concerns. The volume of water to be handled can become substantial.

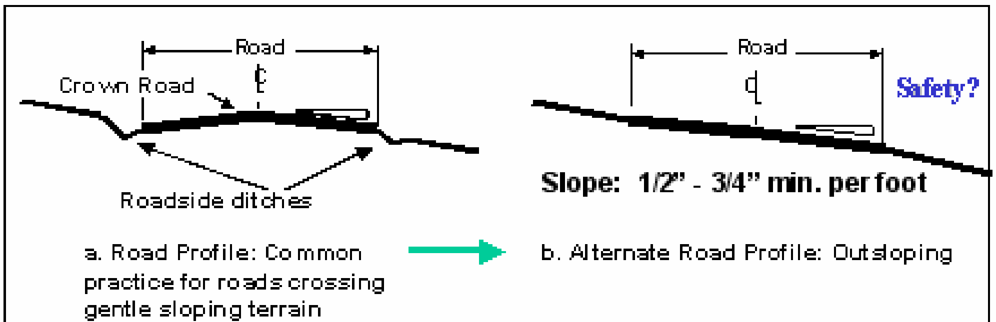


Figure 5-4

With outsloping, we slope the entire road with a normal cross slope from one side to the other, similar to superelevation on a curve, but with no ditching. With this outsloping of the road, as shown in Figure 5-4b, and blending it into the surrounding terrain, concentrated flows are eliminated with no ditches or cross pipes required. The existing general slope sheet flow continues across the road with no interference. This technique should be used with **gentle sloping terrain and low overland sheet flow conditions**. Low traffic flow (low ADT) should also be a prerequisite.

Photo 5-09 shows a typical outsloped road. The terrain is gentle with low sheet flows, which are carried across the outsloped road blending into the natural drainage. This will eliminate concentrating the water flow in ditches and cross pipes and the maintenance of these facilities. Site selection for this practice is critical. A heavy storm may require road maintenance afterward if the flows are substantial enough to cause road surface degradation.

5-09 Outsloping this road proved beneficial, eliminating ditches and cross pipes.

Again, safety should be a concern. Normal cross slopes can be used, alleviating the concern of vehicle safety. Depending on the road surface and amount of flow along with the temperature conditions for the area, however, icing of the road surface may become a problem. This has not happened on the various sites where outsloping has been implemented, but the concern should be recognized and conditions monitored during the winter months.

5.3.2 Practices Related to Roadside Ditches. Ditches drain water away from the road, but often cause various erosion and sediment problems. A typical ditch sketch is shown in Figure 5-5 with common ditch terms of foreslope, backslope, and flowline. In discussing ditches, there are several environmentally sensitive maintenance practices that can be considered.

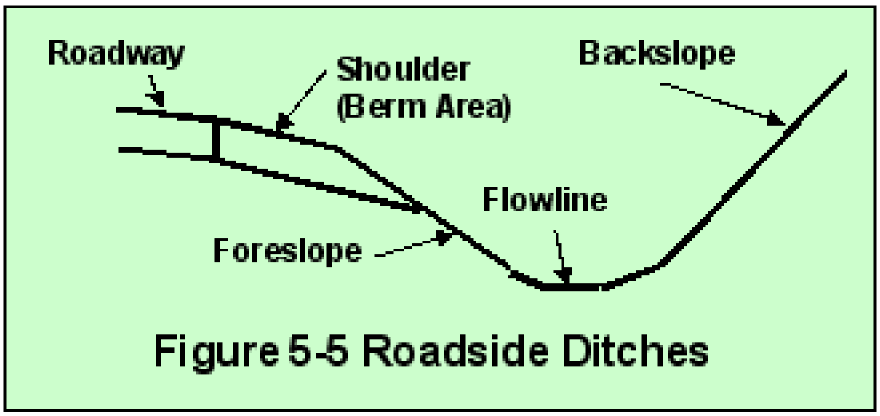


Figure 5-5 Roadside Ditches

5.3.2.1 To Ditch or Not To Ditch? The first question in ditching should always be "Do we need a ditch?" If the road surface drainage can continue to sheet flow away from the road without causing any problems, then a ditch only becomes an impediment, concentrating the sheet flow and compelling further handling through ditches and/or pipes to an outlet along with all the required maintenance. If we can let the road drain naturally by sheet flow into a vegetated area, flows are spread out and thereby slowed down, resulting in the least erosion and sediment potential. At many sites, however, this natural sheet flow drainage conditions is not possible, and ditching is still going to remain the option of choice.


5-10 Trapezoidal shaped ditch.

5.3.2.2 Ditch Shape. Ditches should be shaped and sloped to prevent standing water and must have an outlet. Safety for errant vehicles should also be a consideration. There are many ditch shapes, with common shapes shown in Figure 5-6 with different advantages and disadvantages. For purposes of erosion prevention and the environment, ditch cross sections with a trapezoidal or parabolic shape are desired. These shapes tend to spread water flow and slow it down, which will reduce the erosion potential and subsequent sediment.

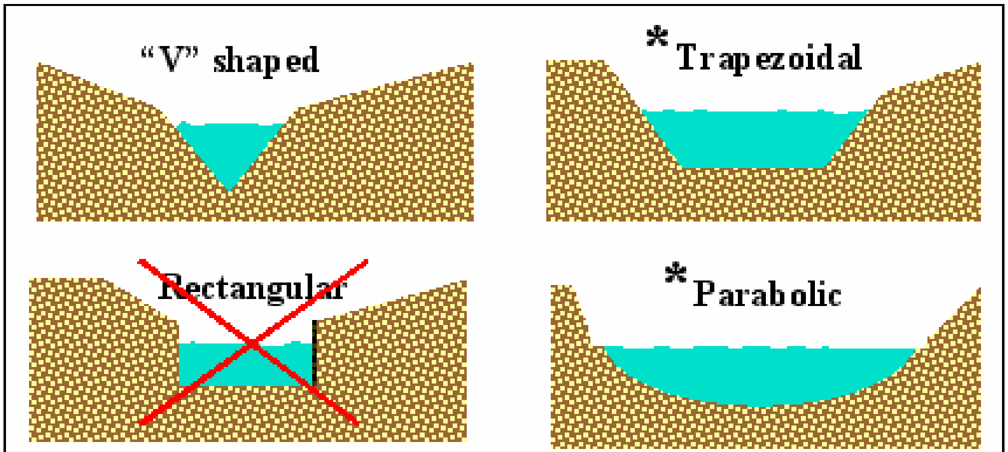
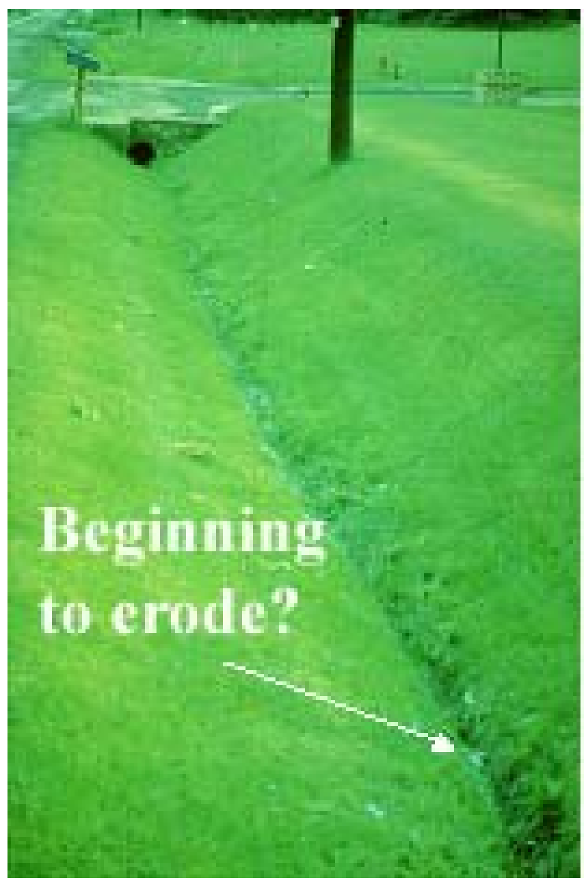


Figure 5-6 Ditch Shapes (*Preferred)

V-shaped ditches are common due to motor grader use in dirt and gravel road maintenance and may not be a problem. A deep V-shape, however, concentrates water flow, increasing its velocity, possibly eroding the ditch's bottom. Deep sharp V-shaped ditches are more prone to this bottom erosion and should be inspected regularly. If water flows and velocity are starting to cause erosion, the ditch can simply be flattened to a wider V-shape. This will again spread the water out and slow it down, diminishing the energy and thereby the erosion potential. Photo 5-11 shows a good grass-lined, v-shape ditch. On close inspection, however, the bottom of the ditch is showing signs of initial erosion. The erosion may not get any worse, but the ditch needs to be watched. If the erosion continues and gets worse, a possible solution may be a simple flattening of the ditch, which would spread the water and slow it down, decreasing energy and erosion potential.



5-11 Grass-lined, V-shaped ditch.

Rectangular shapes give a vertical surface prone to destabilization and erosion without a more substantial surface protection. Rectangular-shaped ditches may also pose a vehicular safety hazard and are not recommended for use.

5.3.2.3 Ditch Slope. Ditch side slopes often dictate the amount of maintenance due to instability and resulting erosion and sediment. The recommended side slope is 4 to 1 (4 foot horizontal to every 1 foot vertical drop). This slope provides greater stability, better support for the road, and is easier to maintain. In addition, this 4:1 slope is a forgiving shape for safety. A vehicle running off the road onto a 4:1 slope will not turn over and has a better chance to recover control without a serious accident.

On many existing roadsides, the terrain or right-of-way limitations do not allow for a proper slope and ditch. We need to keep in mind, however, that the steeper slopes mean greater instability, less road support, harder maintenance, and lower safety levels (see Figure 5-7).

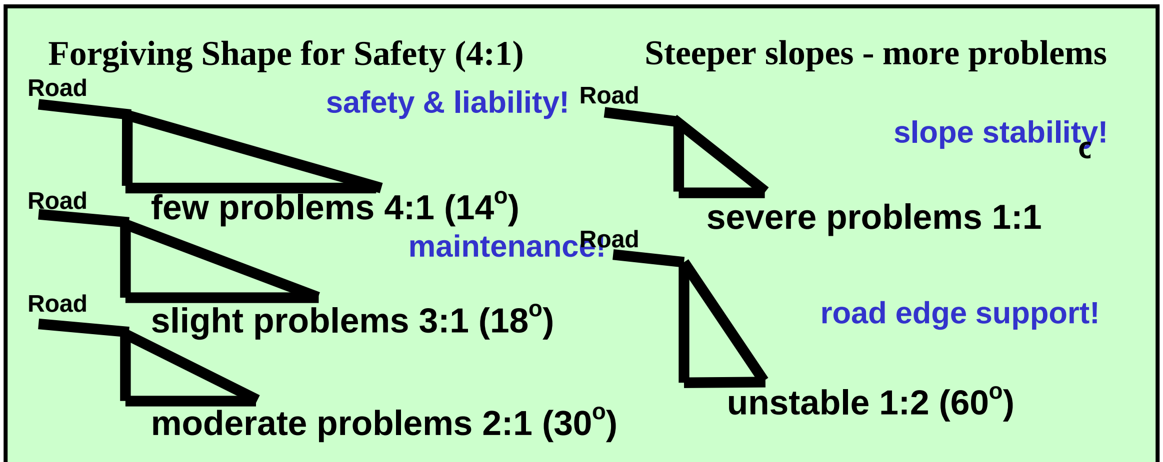


Figure 5-7 Roadside Slopes

Ditches should have minimum longitudinal slopes of 1% or 1-foot drop in 100 feet of ditch. For proper drainage, we need to keep ditch water flowing to an outlet away from the road. Standing ditch water will only result in additional road maintenance. The water will seep back into the road structure, creating the road softening lubricating effect described in Chapter 3 along with freezing and frost heave problems.

5-12 Standing water can only lead to problems.

Flatter slopes slow the water, decreasing ditch erosion while steeper slopes increase velocity, raising ditch erosion potential. On the other hand, flatter slopes will allow sediment accumulation resulting in increased ditch cleaning, but, remember, if there is no erosion, there is no sediment. Find the source of the erosion, fix the erosion problem, and eliminate the sediment.

5.3.2.4 Alternative Ditch Cleaning Practices. By tweaking traditional practices, ditches can be cleaned in an environmentally sensitive way that benefits the road as well. Again, please note that these practices may not be entirely new, but just a modification of something we are already doing.

Watch Weather Conditions. You can avoid potential devastating erosion and sediment events by only cleaning ditches when no substantial rain or storms are predicted.

Conduct Erosion and Sediment Control During Maintenance. Temporary erosion prevention and sediment control practices (refer to Section 5.2.3 for common basic practices) should be used as necessary during the maintenance operation and until vegetation is completely reestablished. Vegetation reestablishment is critical – including seeding and soil supplements and mulching. Seeding for re-vegetation and other vegetative stabilization practices will be thoroughly covered in Chapter 6.

Sectional Cleaning. Common practice is to clean the entire ditch along the entire section of road right to the outlet and directly to a stream. We will look at that direct outlet to the stream and better alternatives, such as outletting into a vegetative filter strip below. However, we will now look at some alternative cleaning practices that can be used in combination with other practices. For example, cleaning upgrade sections first and leaving the last section before the outlet until later avoids excessive erosion. Similarly, cleaning alternating sections of long ditches accomplishes the same result, and if erosion does take place prior to re-establishment of vegetation, the sediment will be trapped in the uncleaned sections that can be cleaned later.

5.3.2.5 Ditch Widening and Slope Flattening. Preventing ditch erosion may be as simple as widening the ditch to spread water flow and slow velocity or flattening the ditch side slopes to slow water velocity entering the ditch. Remember, the slower the water, the less erosive force it has with less potential for sediment pollution. These practices go right back to the parabolic or trapezoidal shapes discussed before.

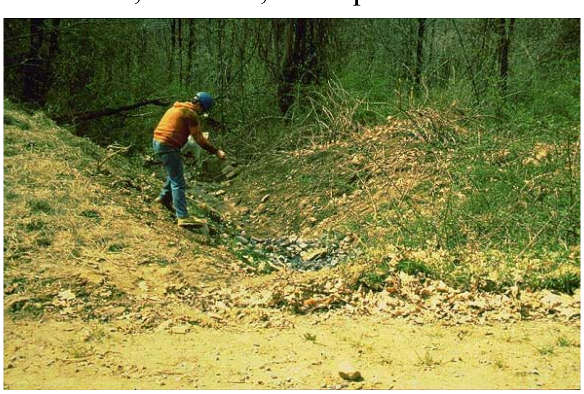
5.3.2.6. Reuse of Topsoil and Vegetative Root Mats. In ditch cleaning, ditch widening and slope flattening operations, we usually clean out the established vegetation and end up with subsoil conditions. In Chapter 2 we saw that “dead” subsoil poses a problem for reseeding to establish vegetation. Ditch work can strip existing vegetation and topsoil, which is usually hauled away and discarded. With a little more work and effort, this material could be reused, and re-vegetation will become easier and more timely. Depending on the natural conditions and the equipment used, the existing vegetative root mass can be stripped, laid aside while subsoil is removed to the proper elevations, and then the root mass reused on the newly constructed surface. This root mass, with proper moisture, will re-establish and may need no other seeding or soil supplements added, thus saving additional maintenance work for revegetation and repair of eroded areas. This practice will be further discussed in Chapter 6 when we look at roadside banks.

5.3.2.7 Ditch / Channel Linings. The water volumes and velocities of ditch and channel flows may necessitate different stabilization methods using different ditch/channel linings. Higher velocities usually dictate a more substantial ditch lining. Each site has to be analyzed to determine what may be required. Charts showing maximum velocities for different linings are available and are good guidelines. A typical chart for natural soil, vegetation and several "paved" linings with the maximum velocities sustained by these linings is shown in Figure 5-8.

Figure 5-8 Maximum Velocities for Various Types of Ditch/Channel Linings

Natural Soil Linings	**Max Velocity (fps)**
– Clean gravel	6 - 7
– Silty gravel	2 - 5
– Clean sand	1 - 2
– Silty sand, clay	2 - 3
– Clayey sand, silt	3 – 4
Vegetative Linings	**Max Velocity (fps)**
– Avg. turf, erosion resistant soil	4 - 5
– Avg. turf, easily eroded soil	3 - 4
– Dense turf, erosion resistant soil	6 - 8
– Gravel bottom, brushy sides	4 - 5
– Dense weeds	5 – 6
Paved Linings	**Max Velocity (fps)**
– Gravel bottom, concrete sides	8 - 10
– Rip-rap sides & bottom	15 - 18
– Concrete or asphalt	18 - 20

As velocities increase, more substantial linings are required to prevent erosion. Remember, however, to keep in mind that if we can spread the water out by widening the ditch/channel and flatten the ditch/channel grade, we can slow the water (reduce the velocity) and possibly negate the need for a more substantial paved lining. Vegetative linings are less costly over the long run when compared to paved linings. Vegetative linings also provide for infiltration and better aesthetics.



5-13 Seeding and mulching may be sufficient to revegetate the ditch.

5-14 A biodegradable netting will prevent erosion until vegetation is established.

For stabilizing new or disturbed roadside ditches with vegetation, practices can range from seeding and mulching only or in combination with biodegradable mats, netting or blankets, to geosynthetics. These materials provide erosion prevention until the vegetation becomes re-established. They usually come in rolls with directions for pinning or anchoring. Many different products are available with many different designs depending on soil characteristics and water flow conditions. They allow vegetation to grow while providing the necessary erosion protection either temporary as for the biodegradable types to more permanent reinforcement provided by the geosynthetics. Keep in mind that geosynthetics are not biodegradable and will remain for an indefinite period of time.

The type of lining is selected based on the steepest grade of the channel or ditch. Velocity and volume of water in

5-15 Many geosynthetic products are available for erosion prevention.

the ditch and the potential for sediment also need to be considered. If the flow is too slow, sedimentation is the major factor; if the flow is too fast, erosion of the ditch and lining material is the major factor.

Of course, any lining should be installed properly. Photo 5-16 shows a biodegradable netting installation. But look at the erosion behind and around the culvert with sediment on top of the netting. We need to make sure we examine the entire area and stabilize accordingly.

5-16 Good netting installation, but problems at pipe outlet need to be addressed.

Vegetation lined ditches offer several advantages including low-cost maintenance. (Refer back to Figure 5-8 for maximum allowable velocities for different types of vegetation-lined ditches.) Vegetation not only protects the soil from erosion by covering the surface and slowing the water flow with the root structure reinforcing the soil layers, but it also removes silts and fines and attached chemicals from storm water allowing infiltration for ground water replenishment. Keeping suspended solids in side ditches improves water quality.

5-17 Use caution when deciding to line ditches with rock riprap.

We must keep ditches from filling with sediment. Always look to the source of the erosion and sediment to determine what corrective measures can be taken.

Higher water velocities may demand more substantial linings such as riprap, as seen in the chart. Reducing water velocity should always be a priority. For instance, widening the ditch allows you to use a less expensive lining.

Here is one word of caution. Riprap is not a good ditch/channel lining choice if further erosion and sediment is likely. The rock riprap will fill with sediment resulting in major cleanup problems. Most likely, the riprap will have to be removed and replaced at considerable expense. This type of operation can strain limited local government budgets. When considering riprap for ditch linings, factor in future maintenance costs as well. Photo 5-18 shows a typical rock riprap use as ditch lining placed during construction. If this area is not stabilized immediately, the riprap will end up filled with sediment during the first rainstorm. Keep future

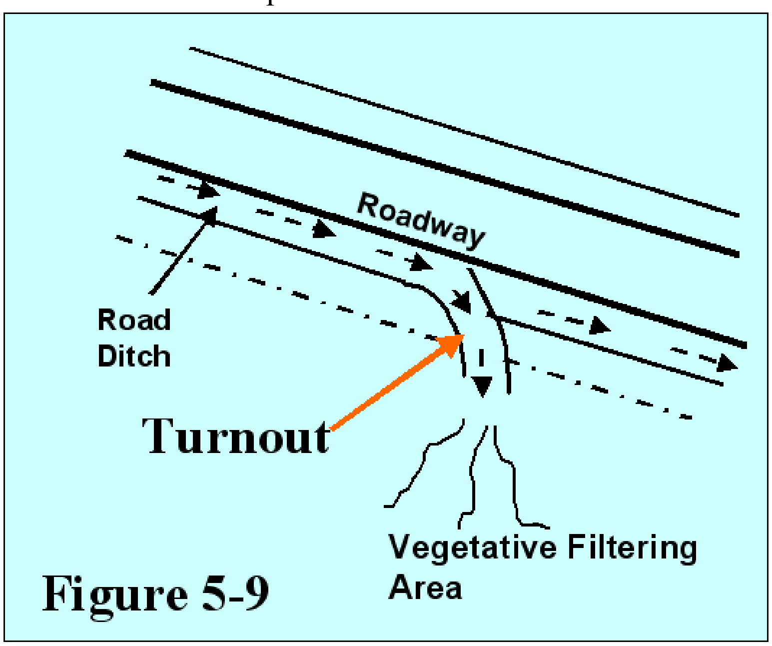
5-18 Riprap placed during construction—looking at the sediment potential, was this a good idea?

5-19 Do not outlet ditch directly to stream—use turnouts into vegetative filter strips!

maintenance in mind when considering any materials or practices at any given site.

5.3.2.8 Ditch Turnouts and Vegetative Filter Strips. Do not outlet ditches directly to streams. Photo 5-19 shows a common situation with ditch outlets. They carry water along with any sediment directly to the stream, which is the low point on the road. We need to change our way of thinking and doing in this regard. We need to consider turning the ditch out prior to that low point or that stream into a vegetative filtering area or "filter strip."

Ditch turnouts and vegetative filter strips should automatically go together. Vegetation filter strips spread the water flow, slow velocity, decrease erosive force, and filter out sediment. The slower water allows sediment to settle. Other pollutants that may have attached to the sediment will also be contained and may break down and dissipate, as described in Chapter 4.



In addition, **more turnouts** should always be an option. Limiting the length of the ditch to a turnout will reduce the amount of water and flow in the ditch, keeping ditch size nominal and reducing water velocity and erosion potential (remember "divide and conquer"). Numerous turnouts may be the answer to the private property flooding/wet area problem created by one long ditch with one turnout at that location. Dumping a huge volume of water with possibly a high velocity from a long downhill ditch can cause erosion and flooding problems on private property. Installation of additional turnouts will break the volume of water into smaller quantities, reducing velocity and erosion and flood potential.

As in other techniques, there are no exact spacing or size requirements for turnouts. Charts are available but usually are based on only one condition such as the longitudinal grade of the ditch. They do not take into consideration the many variables that are different from site to site. Other factors to consider are water volume, ditch slope, right-of-way conditions, and ownership. Water volume can vary considerably depending on the terrain – does the ditch just drain the road surface or the road surface plus the entire hillside adjacent to the road?

Photo 5-20 shows a simple turnout of nominal dimensions and a large turnout that apparently takes a lot of water. In the case of this large turnout, the terrain and off right-of-way conditions created no problems or concerns. But every site will be different. We need to remember that more turnouts mean less water, less erosion, and fewer ponding or flooding problems, meaning less future maintenance.

5-20 Multiple small turnouts mean less water, less velocity, less erosion potential.

Working with Residents. Do you have a problem concerning drainage and private property and dealing with residents? Working with property owners is always a requirement for road maintenance personnel. Most people will respond better if they are approached beforehand with a thorough explanation of the work or project to be completed. A resident whose lawn is saturated from a ditch turnout may not be too enthused about putting in additional turnouts. But if approached prior to the work with a positive attitude and explanation of the benefits, the resident may be willing to at least try the solution to see how it works. The additional turnouts may solve the problem by dissipating the water in smaller amounts over a greater area with no adverse effects anywhere. Maintenance workers should promise to reestablished original conditions if the situation does not improve. Establishing good relationships with residents enhances the road department's ability to implement new practices to get the job done.

5.3.3 Practices Related to Ditches and Road Profile

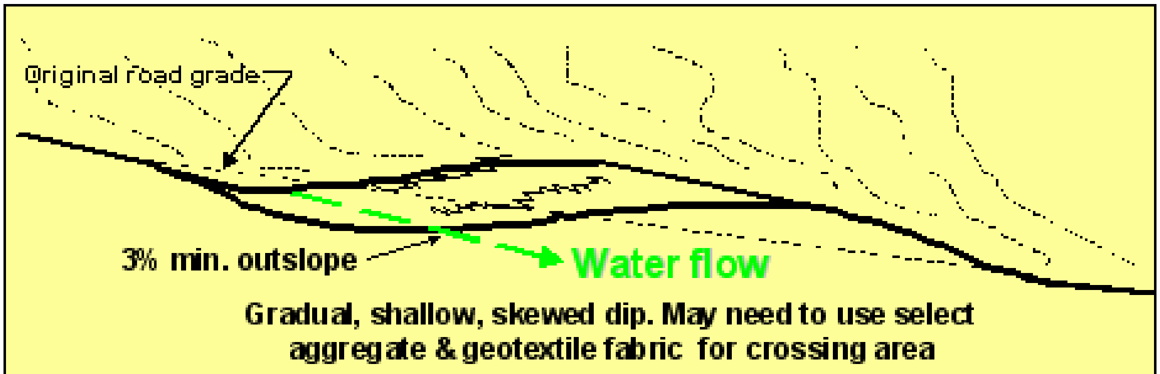


Figure 5-10 Broad Based Dip

5.3.3.1 Broad Based Dips. "Broad based dips" are shallow gradual dips skewed across the road in the direction of water flow, as depicted in Figure 5-10. "Broad based dips" are used when there is a high embankment on one side of the road with a downhill grade. The high embankment does not allow for ditch outlets and would normally require a cross pipe to carry the water to the other side and then to an outlet. These cross pipes are expensive to maintain because of their great potential for blockage and other problems to occur. Without "Broad Based Dips," the water is carried all the way to the bottom of the downhill grade in large volumes at high velocity. The only way to deal with it then is to build large-sized ditches. But this approach creates erosion and sediment-ladened flows that usually outlet directly into a stream. Water also tends to drain down the road surface, building in volume and velocity, producing severe surface erosion.

5-21 Severely eroded road – ideal conditions for broad based dips.

("Water bars" may be a familiar term and are similar to broad based dips, but with a significant difference. Water bars are short, abrupt drainage ways to get water across a road without using a cross pipe. They eliminate water from flowing down the road and can be used to actually block traffic use of the road. They have been most often used on retired logging roads to block traffic and divert water away from the road. Broad based dips can be thought of as water bars stretched out into gradual slopes in order not to interfere with vehicles using the road.)

5-22 Broad based dips can be used in lieu of cross-pipes.

On very low traffic volume roads, broad based dips present an alternative to the costly cross pipes without creating large erosion producing flows. **Used only for ditch flows**, broad based dips should not be used for perennial streams with permanent or intermittent flows. Broad based dips allow the ditch water to flow to the other side joining that ditch flow to a joint outlet or turnout to a vegetative filter strip. The “dip” channel is skewed in the direction of water flow, and the crown of the road is eliminated within this area. The use of multiple broad based dips on a long downhill stretch of road also allows a smaller ditch size to carry the limited volume of water from a shorter section of road, which will not build in volume or velocity within the area between these crossings. This limited water volume and flow should not be substantial enough to do any damage to the reinforced road surface crossing.

5-23 Broad based dip reinforced with large aggregate.

Broad based dips can be graded into the road rather easily with existing road materials. Depending on road materials and conditions, an hour of grading and shaping time should be sufficient to complete a broad based dip. For general guidelines, water volume must be contained in the channel with no overtopping the dip, longitudinal road slopes must be gradual to prevent vehicles from dragging. The best way to test the safe traverse of a broad based dip is to drive the road after installation. If the bounce is too great or dragging is experienced, it may be necessary to reshape the skewed dip.

The dip may have to be reinforced or stabilized with a select aggregate and geotextile separation fabric, since we have water and traffic crossing perpendicular to one another. The need for this reinforcement/stabilization will depend on water volume and flow and the type of existing road material. These fabrics will be discussed in Chapter 7.

Broad based dip spacing and size will vary from site to site depending on road and ditch slopes, volume of water, traffic, terrain, etc. Experienced road personnel know the roads and the water conditions encountered from storms. Their knowledge of the site should be sufficient to establish size and spacing required for broad based dips.

Remember, a greater number of dips decreases the length of road being drained and thereby decreases the volume and the velocity of the water to be handled within each broad based dip.

Road grader operators have to be aware of the broad based dip installations so that they do not think they are washouts or problem areas and reshape the road back to a normal crown. In addition, winter plow operators should be aware of these installations for proper and safe plowing operations.

5.3.3.2 Grade Breaks. "Grade Breaks" are long, gradual breaks in grade on a road with a relatively gradual downhill slope. Grade breaks retain the road crown and require appropriately placed cross pipes. Grade breaks limit water flow by decreasing concentration and velocity from a reduced area of road section, resulting in limited ditch and cross pipe size. This reduction in water volume and flow in turn helps alleviate problems at the pipe outlet. Grade breaks also limit the length of flow and thus velocity down the road surface, eliminating potential surface erosion gullies and rutting.

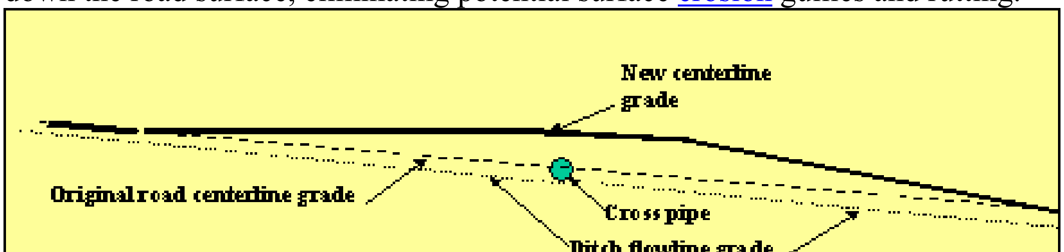
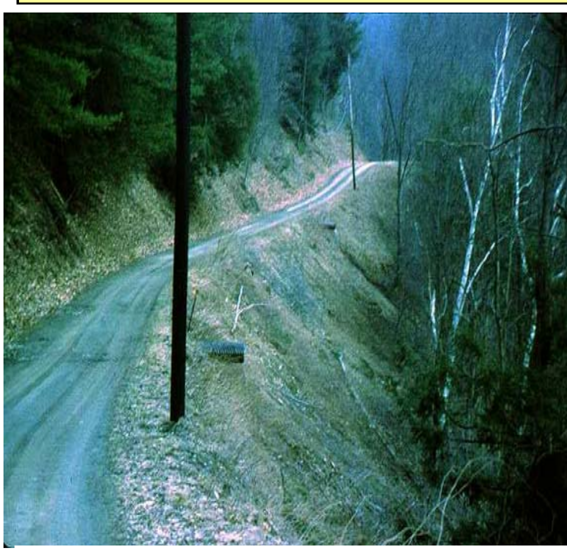


Figure 5-11 Grade Break



5-24 Grade breaks result in short road sections with reduced water volume and flow velocity.

Photo 5-24 depicts typical grade breaks on a road with a long downhill slope. Like broad base dips, there are no exact formulas for spacing or size, again depending on slopes, traffic, volume of water, terrain, etc. Although the photo shows cross pipes at the road low points, cross pipes can be strategically placed and can actually be used to create the grade break. A cross pipe can be installed to effectively meet the ditch gradient, as shown in Figure 5-11, and the road would be built up and over the pipe to create a grade break. Otherwise, cross culverts would have to be installed at a much deeper elevation than the road ditch, resulting in additional potential for pipe blockage, road flooding, or road and ditch erosion. Pipe outlet areas should be continually monitored and erosion protection established as needed. Alternative erosion prevention measures at pipe outlets will be discussed in a later section.

5.3.4 Practices Related to Driveways. Driveways can only be controlled through an ordinance or regulations and a permit system. Each local government should adopt policies and procedures appropriate to their particular situation and resources. Many local governments provide for a cost sharing arrangement with the property owner. The local government may pay for and supply a cross pipe to continue ditch flow, or may do the pipe installation at no cost to the owner. Options as to who does what work and who pays vary considerably from one local government to the next one, but the decision must be set by ordinance or regulation. The main factor is “to have control” so road personnel are free to review the site and determine the best approach to protect both road and environment while providing safe ingress and egress for the property owner and a safe roadway for the motorist.

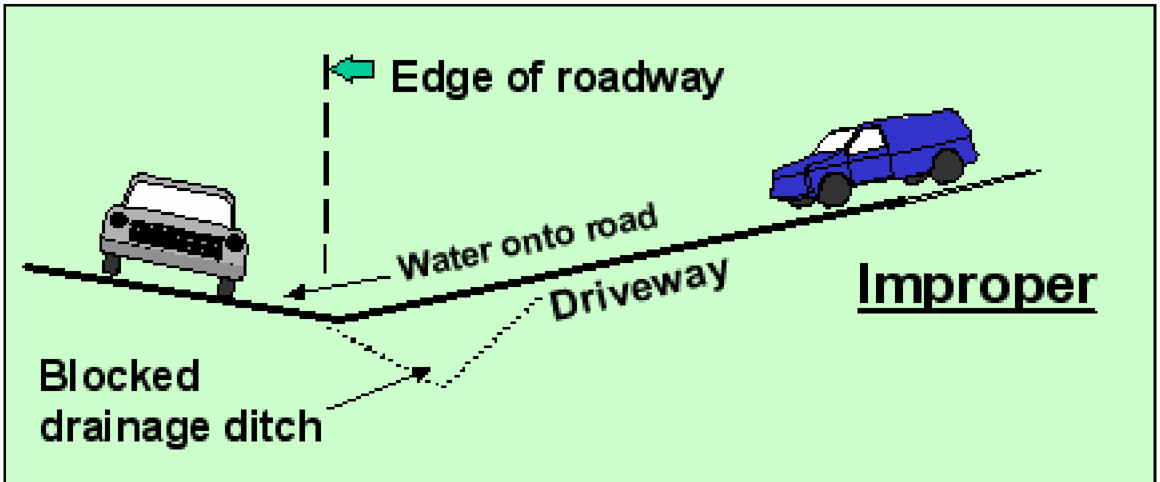


Figure 5-12 Common driveway construction without control

5.3.4.1 Proper Profile. Although driveways should not interfere with normal road and shoulder profile, driveway profiles pose additional problems for proper road drainage. The worst condition results when the driveway slopes downward toward the road and is constructed right to the road edge obliterating the roadside ditch (see Figure 5-12). Even if a pipe is installed to maintain ditch flow, the water draining from the driveway flows onto the road, deteriorating the road surface and causing possible hydroplaning in the summer and icing

5-25 Improperly constructed driveways create recurring road maintenance problems.

in the winter. Continuing ditch flow to drain the road while properly draining the driveway is imperative to ensure vehicle safety, prolong the life of the road and protect the environment. Uncontrolled driveway construction can result in high levels of maintenance, costs, liability, and frustrations, as seen in Photo 5-25. **The low point should be over the ditch line** and the ditch flow maintained.

5.3.4.2 Driveways Over Deep Ditches. There are several options for maintaining good drainage. The most common practice is to install a pipe to carry the ditch flow under the driveway. With the low point remaining over the ditch line, the road and the driveway will both drain to the ditch off either side of the drive (see Figure 5-13).

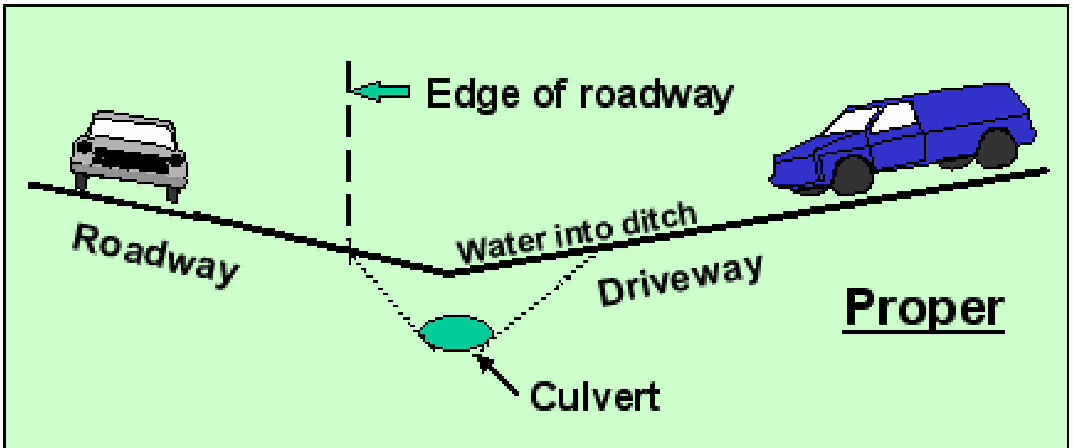


Figure 5-13 Proper driveway construction with deep ditch

An alternate method for medium-depth ditches is to use an open-top culvert or a box with an open grate (see Figure 5-14). These can be pre-fabricated items or homemade. The photo inset in the figure pictures two types of pre-fabricated units, one all-plastic type with a choice of colored grates. Pre-fabricated units are built to withstand truck traffic when installed following the respective manufacturer's requirements.

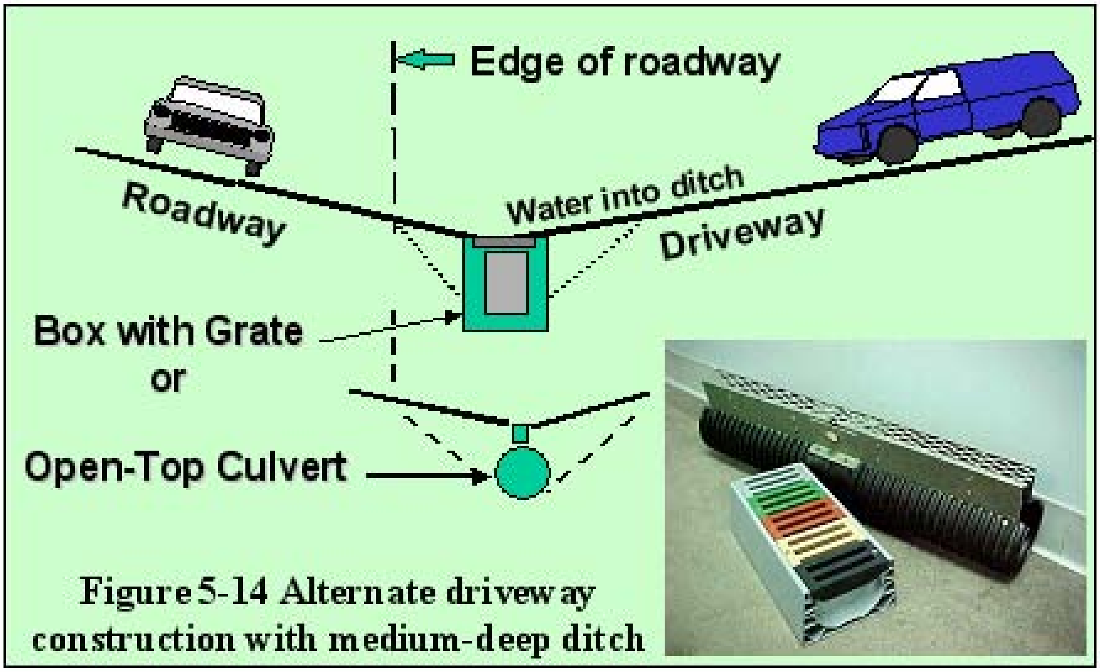


Figure 5-14 Alternate driveway construction with medium-deep ditch

Several cautions should be noted in using these alternatives. First for safety, consider animals and bicycles in determining the appropriate sized openings for drainage in homemade installations. Secondly, although these are definitely beneficial in paved road and driveway conditions, they can be applied for paved driveways to unpaved roads. Water coming off an unpaved driveway may cause problems with clogging the openings or drainage way with eroded driveway material. A paved driveway usually does not present this problem. Photo 5-26 shows an ideal condition for an open-top grate across the drive to collect any water without having to alter the driveway grade.

5-26 Open-top grates may be used on paved driveways.

5.3.4.3 Driveways Over Shallow Ditches. Of course, if ditches are shallow and water flow is not substantial, the ditch may be continued across the drive, as shown in Figure 5-15.

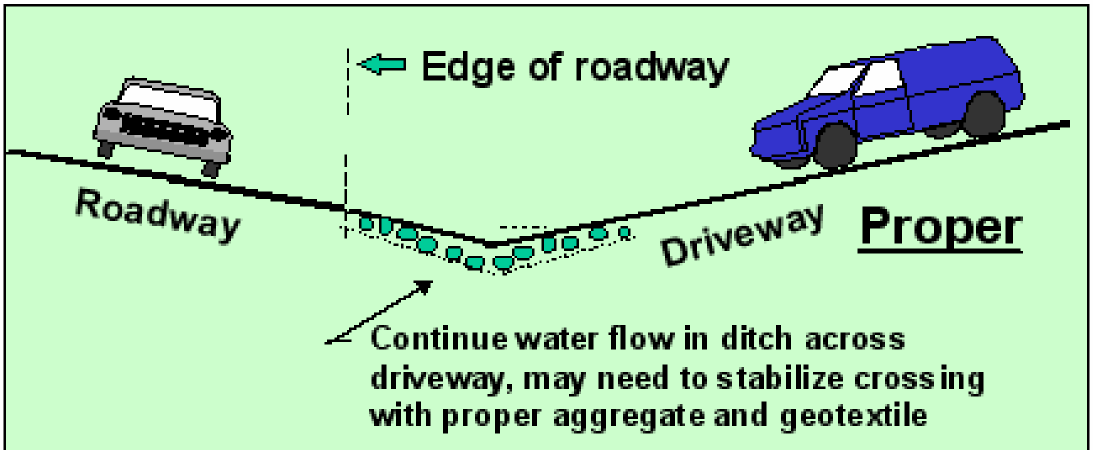
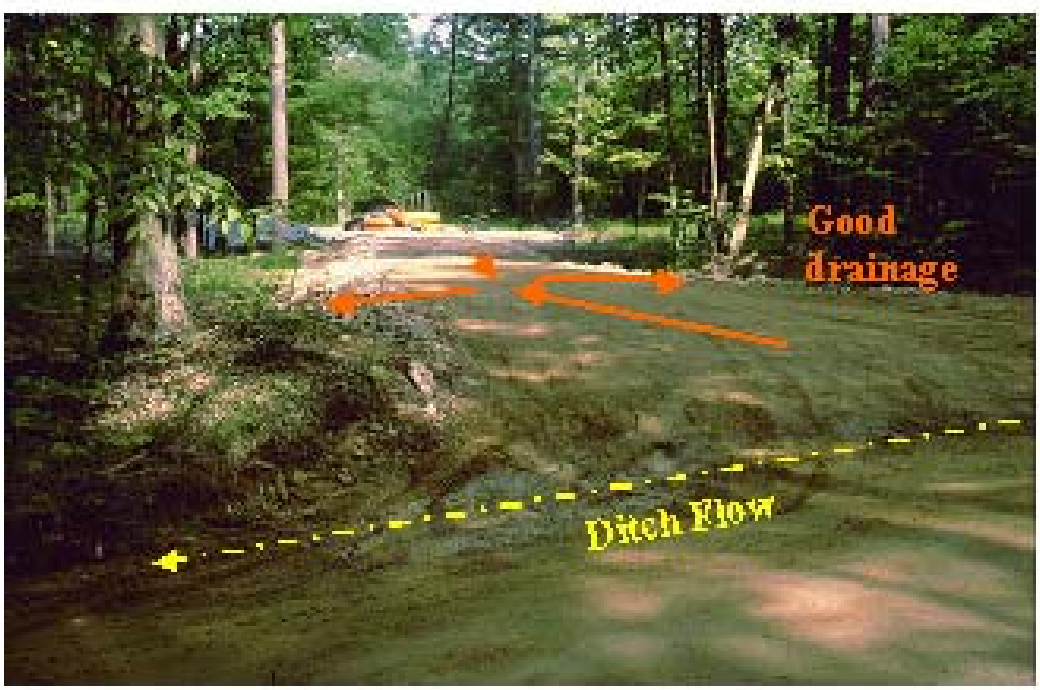


Figure 5-15 Driveway construction with shallow ditch

Carrying only ditch flows during storm events, the shallow ditch should be no problem for vehicles to traverse. This area may need to be stabilized with proper aggregate and a geotextile separation fabric for crossing traffic. Geotextile separation fabrics will be discussed in Chapter 7. Photo 5-27 shows a newly constructed access driveway to a gas facility. The driveway was graded to drain away from the road and



5-27 Gas facility access driveway designed to drain away from road.

away from the gas facility to a low point on the driveway and then off into the wooded area (vegetative filter area) on either side.

Of course, every road and driveway site will have different conditions with different problems. Sometimes good solutions are hard to find, as shown in Photo 5-28. Each site should be evaluated and designed for the best drainage and greatest safety.

5-28 Sometimes good solutions are hard to find!

5.3.5 Practices Related to Culverts. Culverts or pipes are enclosed channels designed to direct stream or ditch water away from the roadway. Culverts come in various materials and shapes. Selection depends on specific applications or particular needs such as durability, strength, cost, corrosion resistance, abrasion resistance, flow characteristics, and installation requirements.

5-29 Common Pipe Materials

The three common materials available are concrete pipe, corrugated metal pipe, and plastic pipe. as shown in the photos. Whatever the shape or material, the culvert has to have adequate strength for support of both fill material and traffic loads. Deep installations have to support the fill material above the pipe. Traffic loads are a minor concern with deep installations. However, with shallow installations traffic is ***the*** major concern.

First, we need to understand how vehicle loads are distributed to the road. All vehicle weight is transferred to the road through the tires. But the area where the tire contacts the road is small. The pounds per square inch over these tire contact areas are at the maximum. However, the load is distributed out over a greater area as it is transmitted down into the road structure, as depicted in Figure 5-16. The greater the road structure depth, the less pounds per square inch loading occurs because the same amount of load is distributed over a larger area.

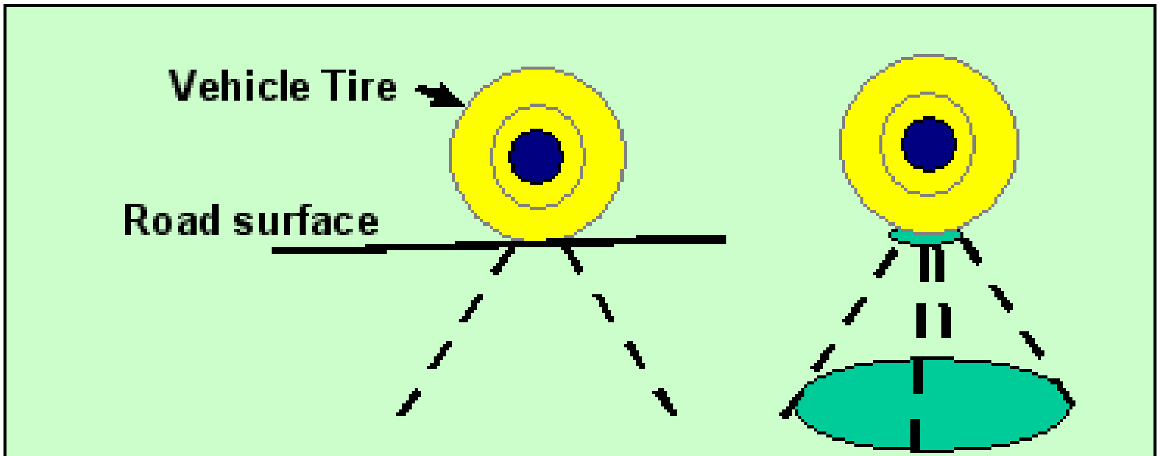


Figure 5-16 Vehicle Load Distribution

In addition to load distribution, it is also important to understand the impact of moving traffic. Traffic exerts a vertical force due to weight and a horizontal force due to motion. These two forces combine to produce an impact force hitting the road surface. The more shallow the pipe, the greater the traffic impact force. It is important to keep a minimum of twelve (12) inches cover over the pipe below the subgrade of the road to minimize the effect of this impact factor. Pipes larger than 24-inch diameter may need additional cover.

Concrete pipe is considered a rigid pipe while corrugated metal and plastic pipes are considered flexible. Rigid concrete pipe cannot flex, and the pipe itself carries most of the load, but it is important that the pipe be given uniform support throughout its entire length to develop its maximum strength. The load-carrying capacity of flexible pipe depends on the support it gets from the surrounding earth. Proper compaction of the backfill material in layers is critical to develop maximum strength. Many pipe failures

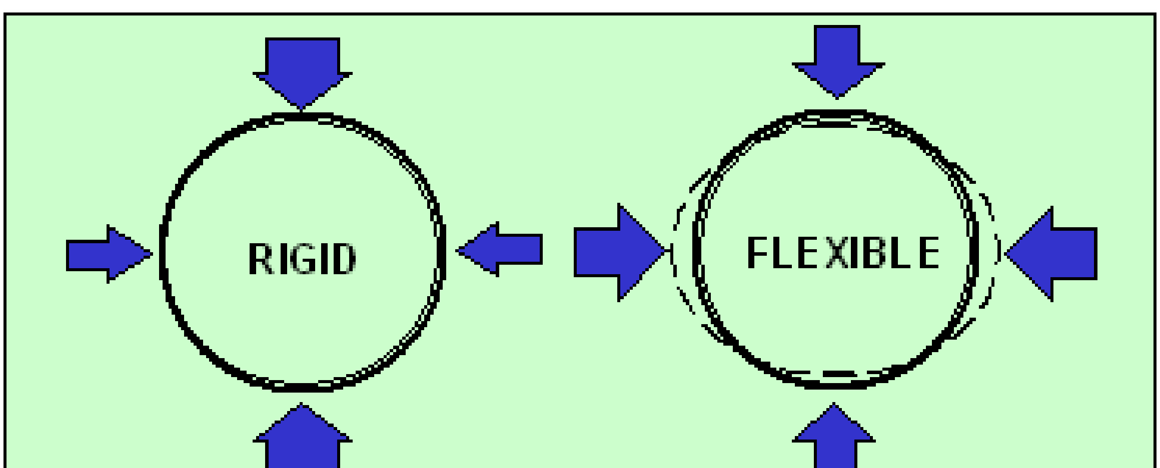


Figure 5-17 Pipe Load Support Characteristics

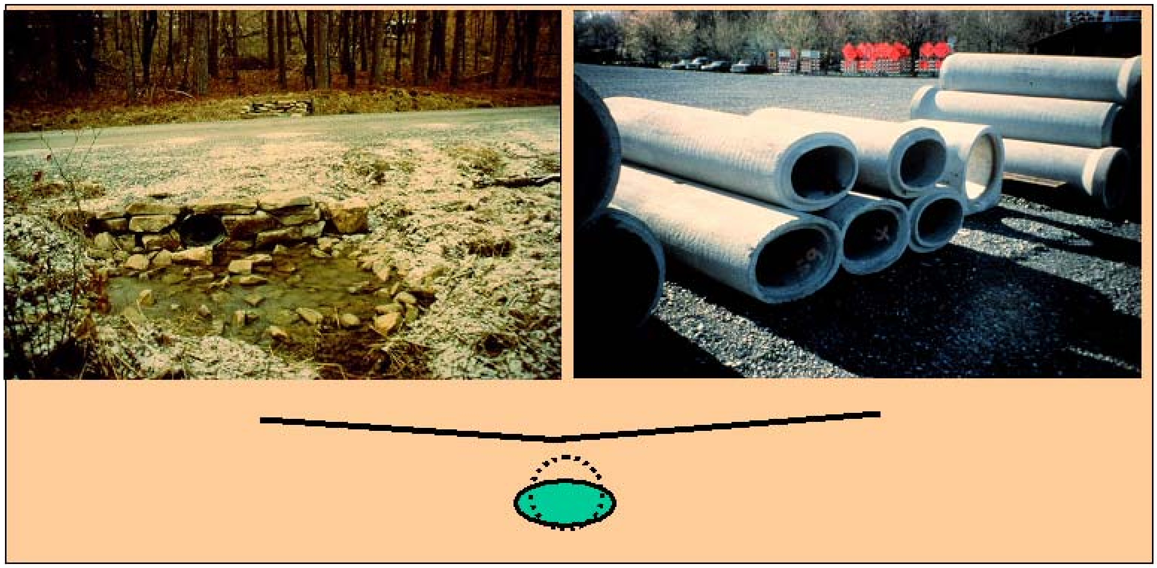
occur due to improper backfill material compaction. Traffic loads, particularly in shallow installations, will cause the pipe to flex, causing cavities to form around the pipe, eventually undermining the whole installation. Properly compacted backfill provides the necessary support to limit flexing movement and possible resultant failure. Figure 5-17 depicts the pipe load support characteristics of rigid and flexible pipes.

Culverts can be a primary cause of erosion and sediment. Culverts normally restrict water flow as it enters the culvert, increasing velocity, causing turbulence, and increasing energy at the outlets. Shallow installations across the road can also cause continual road maintenance work. With a little understanding and consideration, these problems can be alleviated.

5.3.5.1 Shallow Culvert Installations. Most cross road shallow culvert installations are dictated by the surrounding conditions and terrain. But when the culvert is too shallow, heavy traffic can cause problems. As discussed above, flexible type pipe tends to deflect under traffic, causing road materials to shift and eventual road deterioration to occur. Cross-pipes of 24-inch diameter or less need that minimum of one foot of cover material over the pipe beneath the structure of the road. This will protect the pipe from the impact forces of moving traffic.

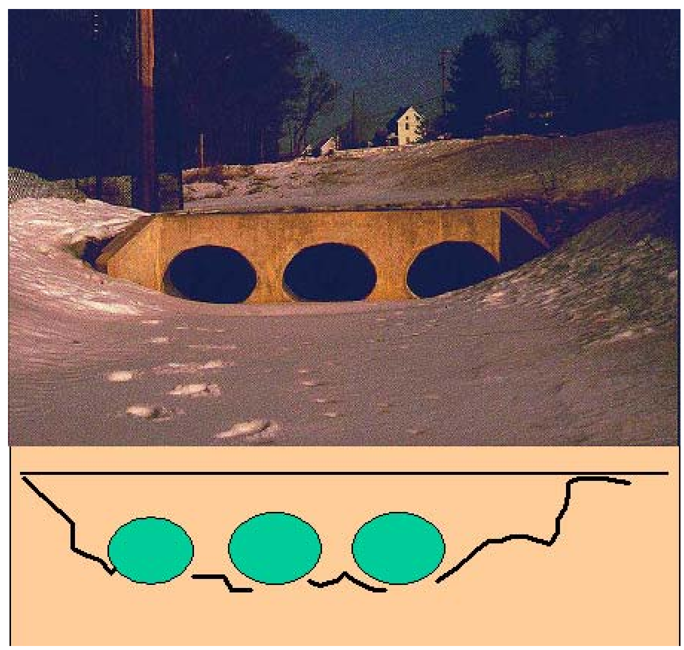
5-30 Shallow pipe installations can cause continual road deterioration.

When adequate cover cannot be maintained, there are alternatives. A rigid pipe (concrete, cast iron, steel) will not deflect to the detriment of the road. A “squash pipe” or elliptical pipe will allow for proper flow capacity but will give additional cover for protection. An equivalent 18-inch diameter corrugated metal “squash pipe” is 15 inches in height. This extra three inches of cover can be significant when it comes to traffic loads and resulting road degradation. Rigid concrete pipe does come in an elliptical shape, giving a double advantage of pipe rigidity and extra cover.



5-31 Shallow installations: use rigid pipe, squash pipe, or elliptical concrete (rigid) pipe.

Another consideration is the use of multiple pipes of smaller diameter, allowing more cover but still providing adequate flow capacity. To use multiple pipes, there are a few rules to keep in mind. Flow capacity is directly related to the area of the pipe opening. This means that two 12-inch diameter pipes do not equal the flow capacity of one 24-inch diameter pipe. (Remember back in high school mathematics, the area of a circle is πr^2 or 3.14 times the radius squared.) Another rule is to make sure the pipes are installed far enough apart to enable adequate compacting of the backfill material between the pipes.



5-32 Shallow installation: Use multiple pipes of smaller diameter, allowing more cover with same capacity.

The use of multiple pipes usually brings comments regarding clogging. Any pipe can clog. One of the simplest solutions, particularly with metal or plastic pipe, is to cut the inlet end of the pipe on a slant or bevel. Any debris flowing toward the pipe will tend to ride up the slant, and water will continue to flow through the pipe. If multiple pipes are used, staggering the inlet ends so that they are not parallel in one line perpendicular to flow will reduce the probability of clogging. Each pipe inlet end is extended a little further (offset) than the pipe beside it. When large debris, such as tree limbs, comes down stream, it will be forced to an angle that is skewed across the pipes, allowing water to continue flow through the pipes (see Figure 5-18).

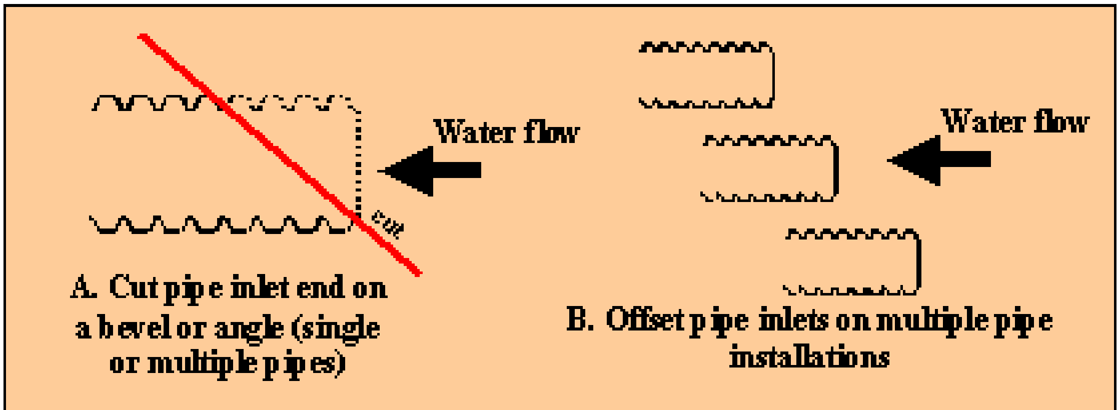


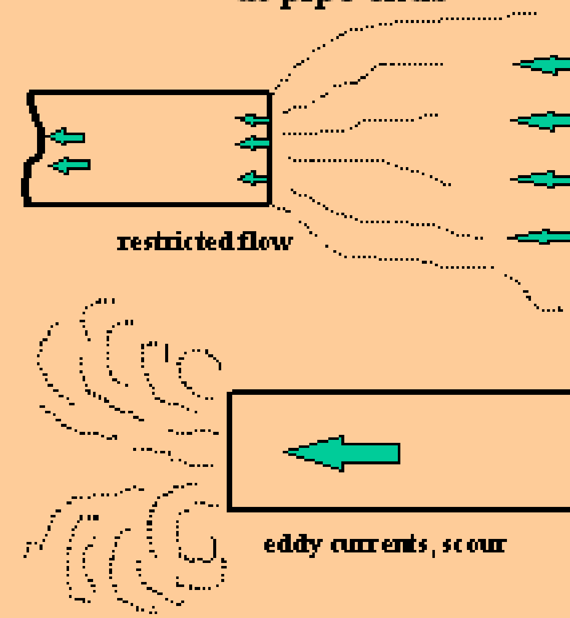
Figure 5-18 Recommendations to Help Eliminate Pipe Clogs

5.3.5.2 Fords on Perennial streams. Ford crossings eliminate the need for a pipe. Several states have numerous existing fords along with related erosion and sedimentation problems. If there is a ford crossing, and it is to remain, the crossing needs to be stabilized and area drainage altered to flow away from the site. Stabilization can be accomplished with select aggregate and geosynthetics with several variations being available (e.g., aggregate and geotextile separation fabric, perforated geoweb filled with aggregate – discussed in Chapter 7).

5-33 Existing fords should be stabilized to prevent erosion and stream degradation.

5.3.5.3 Culvert End Structures. Here are some ideas to reduce future maintenance problems. As mentioned above, when water flows into a pipe, it normally is restricted, as shown in Figure 5-19. This restriction increases the velocity of the water and its erosive force. When water flows out of the pipe, eddy currents develop, swirling water back around at the sides of the pipe, as also shown in Figure 5-19, causing erosion and scour. Straight, smooth transitions into and out of the pipe reduce turbulence and erosion at culvert ends.

Figure 5-19 Flow characteristics at pipe ends



Straight transitions in and out of the pipe, however, are not always possible. Roadside ditch water flowing parallel to the road must be turned to flow through a cross pipe. Even in straight

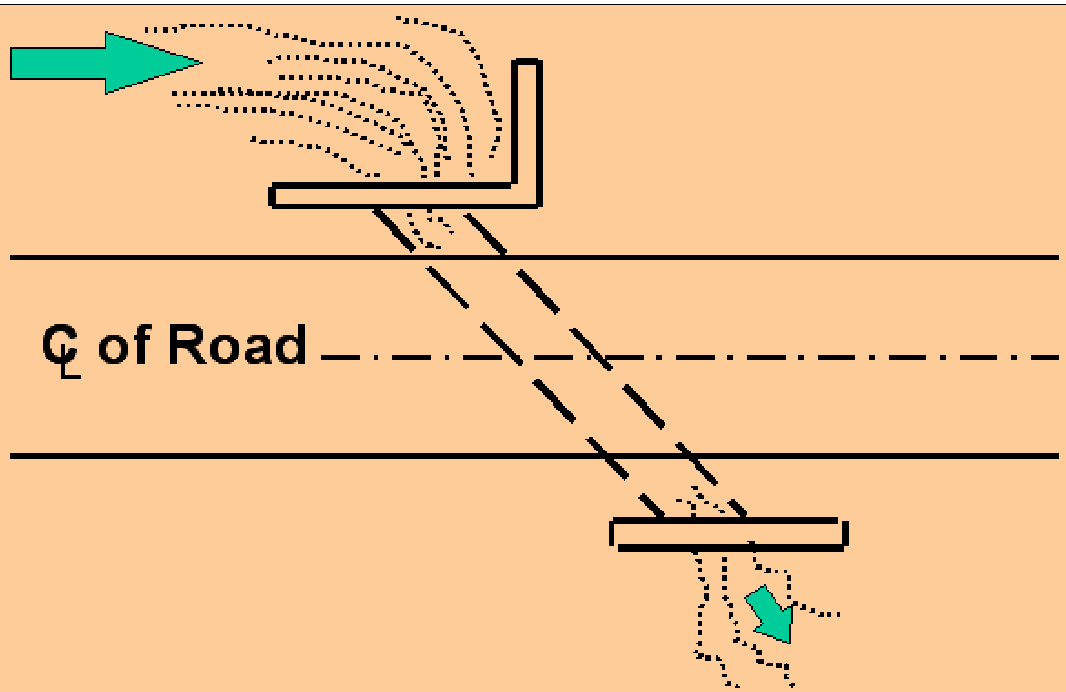


Figure 5-20 Roadside ditch flows need to turn through the cross-pipe – end structures protect against erosion

transitions, circumstances may cause erosion problems on either pipe end. Culvert inlet and outlet protection is important in the prevention of erosion in these areas.

Inlet and outlet structures not only protect the embankment from undercutting water currents and eddies, but also help anchor the culvert and help prevent crushing of the pipe ends from heavy traffic or equipment, A variety of materials can be used for end structures, from prefabricated units and gabions to cement concrete and flagstone to native stone that may be available on site. Native stone not only becomes cost effective but also is environmentally aesthetic, blending in with the natural conditions. The series of photos show different types of end structures.

5-34 Various materials can be used for end structures.

5.3.5.4. Aprons at Culvert Outlets. Culvert outlets, even with an end structure, may still pose a problem with the flow discharge energy. It may be necessary to create a conveyance channel to establish a stable discharge point. For example, a simple pre-

5-35 Typical flared end sections.

fabricated flared end section (concrete, metal, plastic), as shown in Photo 5-35, provides an apron to spread the water flow and dissipate energy. Photo 5-36 shows a metal flared end section on plastic pipe.

Rock riprap can also be used at culvert outlets effectively. The first photo is a new installation with seeding and mulching around the rip-rap. The vegetation, once established will enhance the area aesthetics. The size of rock and the dimensions of an apron will depend on pipe size, discharge volume and velocity, and slope of the outlet channel or terrain. Charts providing guidelines are available. Using riprap for an apron, however, should not be so technically challenging. Experienced road personnel know the water flow amounts and the potential problems at each specific pipe outlet site. They can size the apron based on their past experience. Then, road personnel should follow up with field inspections during and after the next several rainstorms. If erosion is evident past the riprap limits, expand the apron and inspect again. In Photo 5-38, rip-rap was placed from the pipe outlet down the slope as an energy-dissipating channel.

5-36 Metal flared end section on plastic pipe.

5-37 Rock rip-rap at pipe outlets spreads flow and dissipates energy.

5-38 Using rip-rap for erosion prevention at culvert outlet.

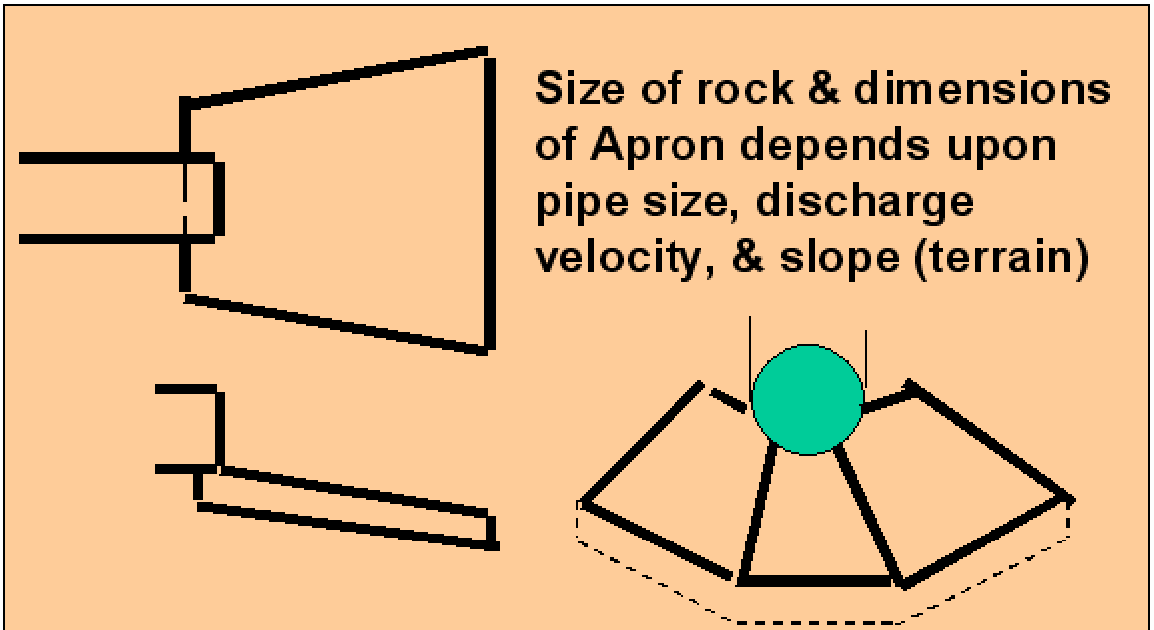


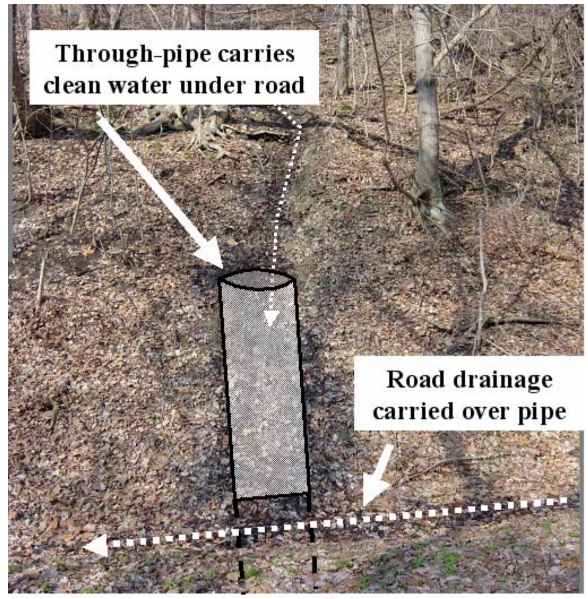
Figure 5-21 Aprons at Culvert Outlets

Although native stone may be the aesthetic choice of material, depending on location, even brush and tree stumps can be effective in dissipating flow energy of water.

5-39 Brush, tree stumps, etc. can be effective energy dissipaters.

5.3.5.5 "Through Drains." Through drains are cross culverts installed strategically to handle springs or spring seeps flowing perpendicular to the road. These drains carry the flow under (through) the road to the other side. Through drains allow water to continue down the path it traveled before the road was built. Because this usually clean water never enters the ditch, it stays clean. The photos depict typical through drain placements. The drains prevent roads from intercepting native ground water flows. If we establish a through drain to allow this natural flow to continue without entering the road ditch, we solve several problems. In addition to keeping the spring water clean, we do not have to handle the water via the road ditch. This reduces ditch flow and potential erosion problems in the ditch and at the ditch outlet. With reduced flow we also may be able to reduce the size of the roadside ditch.

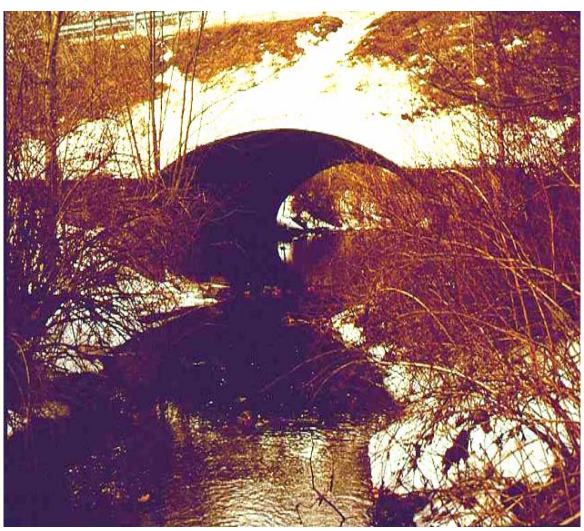
5-40 Through drains keep springs and spring seeps out of road drainage facilities.



5-41 Through drains keep water clean.

If the spring flowing into the ditch has existed for a number of years, the spring's natural downhill channel may no longer exist. This channel may have to be reestablished, keeping proper erosion prevention in mind.

5.3.5.6 Large Culverts in Perennial Streams. Large culverts in perennial (continual flow) streams provide a prime opportunity to enhance the natural stream environment. With new or replacement installations, a pipe culvert or box culvert can be sized to accommodate both flow and the natural streambed. Observe the existing streambed grade and average surface elevation. Set the bottom of the culvert at the required depth to establish a natural streambed through the culvert. Add stream-like material in type and size to minimize disturbance.



5-42 Over sizing culverts to allow natural streambed conditions through the culvert maintains the stream ecosystem.

Another option is to use a metal plate arch without a bottom. The arch spans the stream, resting on footers at each side. This practice maintains the stream ecosystem and still provides the necessary conveyance for proper drainage. This option also enhances protection against undermining of the culvert due to seepage around the pipe (don't underestimate those little crayfish "critters" from burrowing alongside a culvert in their attempt to move up stream, creating water channels along the outside of the culvert that can initiate an undermining process).

5.3.6 Combination Practices. The next two practices combine new techniques with practices described previously. The use of any of the various practices in combination will depend on analysis of the existing site conditions.

5.3.6.1 The Stream Saver System. Commonly, a road's low point is directly over the stream. For many years, this condition seemed to be the most practical and effective way of draining the road. Roadside ditches could be carried directly to the low point and outletted directly to the stream with a cross culvert carrying the stream under the road.

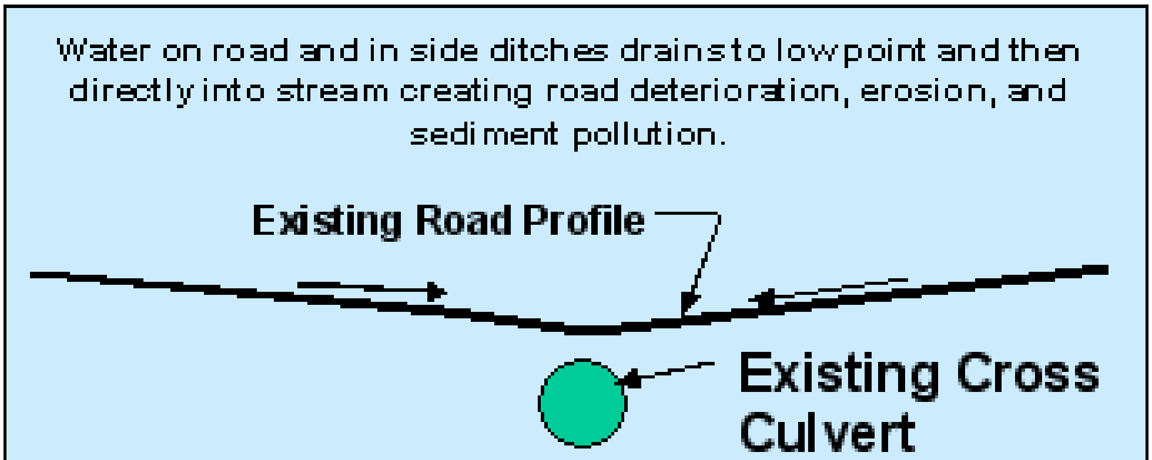
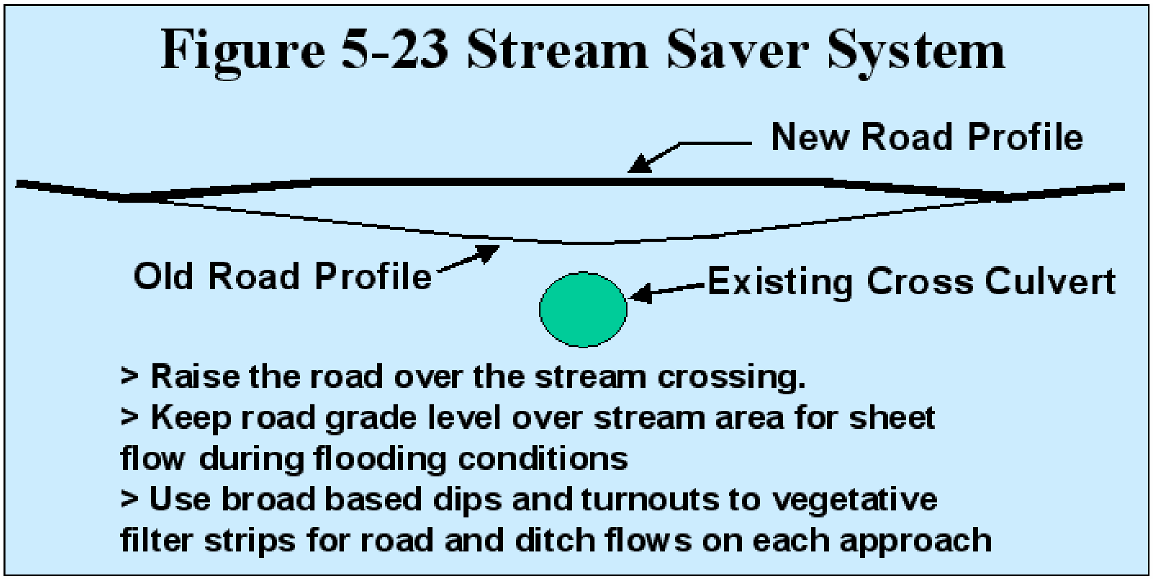


Figure 5-22 Common Practice – Low Point Stream Crossing on Existing Road

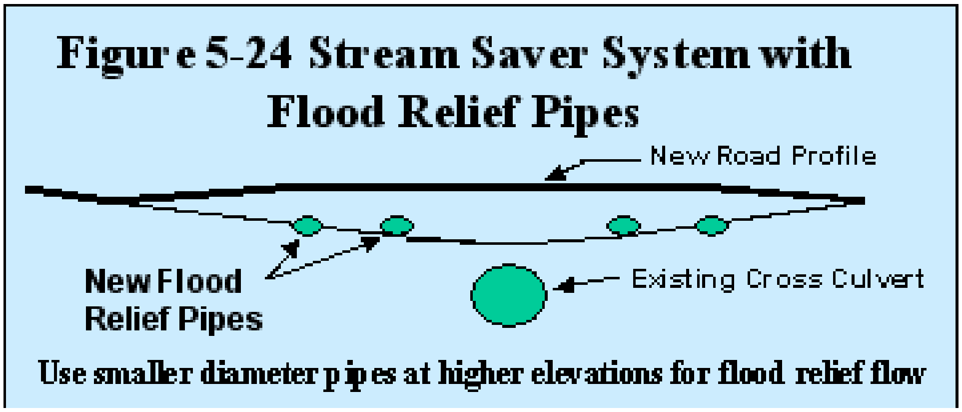
But this concept centered on the road only. An analysis of its total impact revealed some problems. First, everything drains directly to the stream, including any and all sediment and other pollutants. A deeper look revealed it wasn't really all that good for the road, either. Under the scenario illustrated in Figure 5-22, if the stream flow exceeds the culvert capacity and overflows the road, we have created a v-shaped channel, although flat, to concentrate the flow and increase the erosive energy. This condition can cause erosion of the road material and continual road maintenance with every major storm.



5-43 Stream Saver System – raised level road with ditch turnouts to vegetative filters.

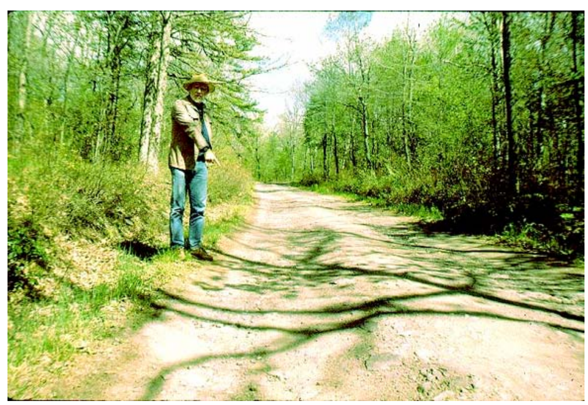
The solution is to implement a "Stream Saver System." Raise the road over the stream crossing, creating a level area extending away from the stream on both sides. This level road grade will allow sheet flow during flooding conditions, if the cross pipe cannot handle the flow. Using broad based dips and turnouts to vegetative filter strips for the road and ditch drainage on each approach as conditions warrant will avoid direct sediment input into the stream and alleviate some flood flow. If pipe capacity is severely limited, a flood flow relief crossing can be established away from the stream depending on the existing terrain and land uses. This crossing can be stabilized as a low water crossing (refer to Chapter 7 for a description of a stabilized low water crossing using geosynthetics).

In raising the road, additional smaller cross pipes could be installed at higher elevations than the flood flow relief cross pipes. Depending on depth of new material to raise the road, these pipes may need only to be laid on the existing road surface or partially excavated into the existing surface. In certain storms, these pipes would handle the additional flow without overtopping the road. Although additional pipes mean more maintenance, these flood relief pipes will only come into use when substantial storms exceed the capacity of the main cross pipe and will keep the road intact.



5.3.6.2 Multiple Culverts. Under certain conditions, multiple culverts at various elevations may be the answer. As an example, an existing road traversing a wetland area had existing cross culverts to carry the perennial flow from the naturally formed channels. Both sides of the road, however, had substantial wetland areas abutting the road embankment. Under normal conditions, the pipes handled flow adequately. The watershed, however, being quite extensive, guaranteed that almost any storm would overtop the road, causing some washout of road material into the stream and wetland. A stream saver system was implemented. The installation of smaller pipes at higher elevations and at locations across the extent of the adjacent wetlands gave an additional benefit to the wetlands. As the water level rose during storm conditions, the additional pipes handled flow and kept velocities and currents to a minimum, maintaining a more stabilizing effect on the wetland habitat.

5.3.7 Major Reconstruction: Raising the Road. Raising the road involves major filling of the road cross section between high banks. Before we get into the details for this work, we should understand the reason and basis for the road being in this condition. Referring back to the beginning of this chapter in Section 5.2, we mentioned the typical cross section of many roads depicts a low road surface with high roadside banks on each side. This is particularly the case in forested areas. In almost all cases, this condition is the result of years of traditional road maintenance.



5-44 Remember this photo? Look at the banks on either side of the road.

Routine road maintenance practices (road grading, snow removal, shoulder cutting, ditch cleaning, etc.) combined with the wear and tear of traffic and natural erosive forces have the cumulative effect of lowering the road elevation in relation to the surrounding terrain. As the road profile drops, or becomes entrenched, water draining to the road is trapped and concentrated in parallel ditches, and the road begins to function as a channel for water flow. This entrenched road profile makes installation of crosspipes, turnouts, and other drainage features to get the water away from the road increasingly challenging. Raising the road can eliminate the persistent maintenance difficulties associated with this entrenched condition.

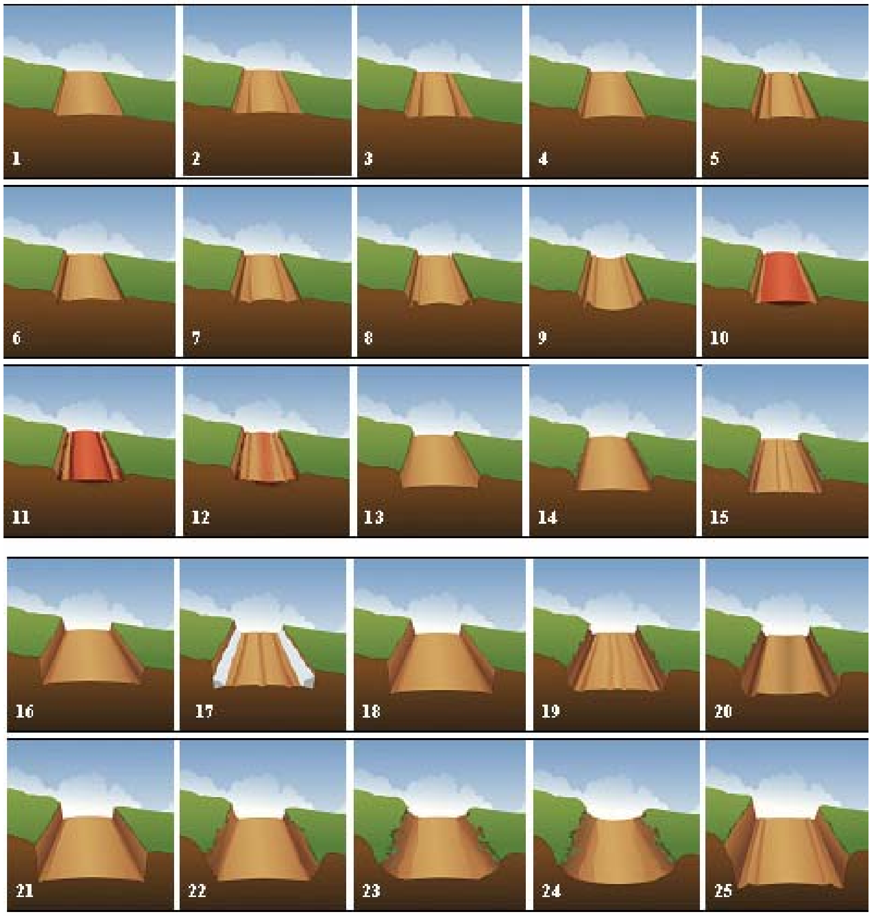
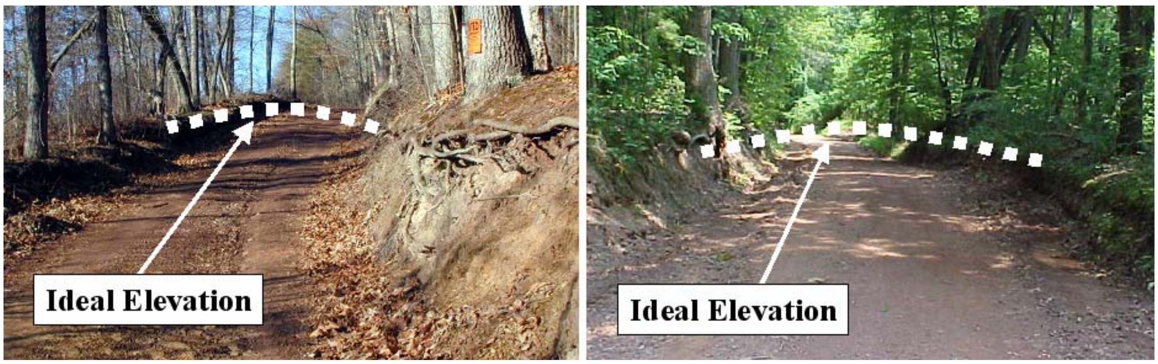


Figure 5-25 The Sequence of Road Entrenchment

Looking at the sequence of photos in Figure 5-25, one can view the lowering of the road surface through the years establishing those high banks on either side. The new road (#1) starts to show surface rutting (#2). The ruts get worse (#3) until grading operations re-establish the profile and attempt to create a better ditch gouging into the bank for drainage (#4). The banks' vertical surfaces start to fall in, and, along with the eroded road materials, create the need for ditch cleaning . Repeated maintenance operations of blading and grading along with ditch cleaning (#5-8) finally results in a need (#9) for additional material as the road crown is lost. Material is added (#10) and the process starts again. This repeated maintenance over the years as more material is lost causes the road to become more and more entrenched (#11-16). Snow removal becomes a problem with the snow being piled along the banks, aggravating the problem (#17). This entrenchment causes the road to act as the drainage conveyance channel, resulting in enhanced erosion of the road and banks and sediment-laden ditches. This, of course, leads to greater road maintenance as the road becomes deeper and wider year after year (#18-25).

5.3.7.1 Raising the Entrenched Road. We can break this cycle. We need to restore the road to its original surface elevation. This could mean substantial fill and a major work effort. Fill material becomes a prime cost in this practice. There are local governments, however, that can obtain free fill and can load and haul the material with their own equipment. Free fill and use of in-house equipment reduces the cost although it will still be a major work effort. Photo 5-45 shows two roads that would be ideal candidates for road raising. Both of these roads have severe drainage, erosion, and sedimentation problems requiring substantial and continual maintenance. But returning



5-45 Good candidates for "raising the road."

these roads to their original elevation could significantly cut maintenance costs. Many roads could be raised to eliminate the banks on both sides, providing excellent road drainage conditions with much less erosion and sediment pollution.

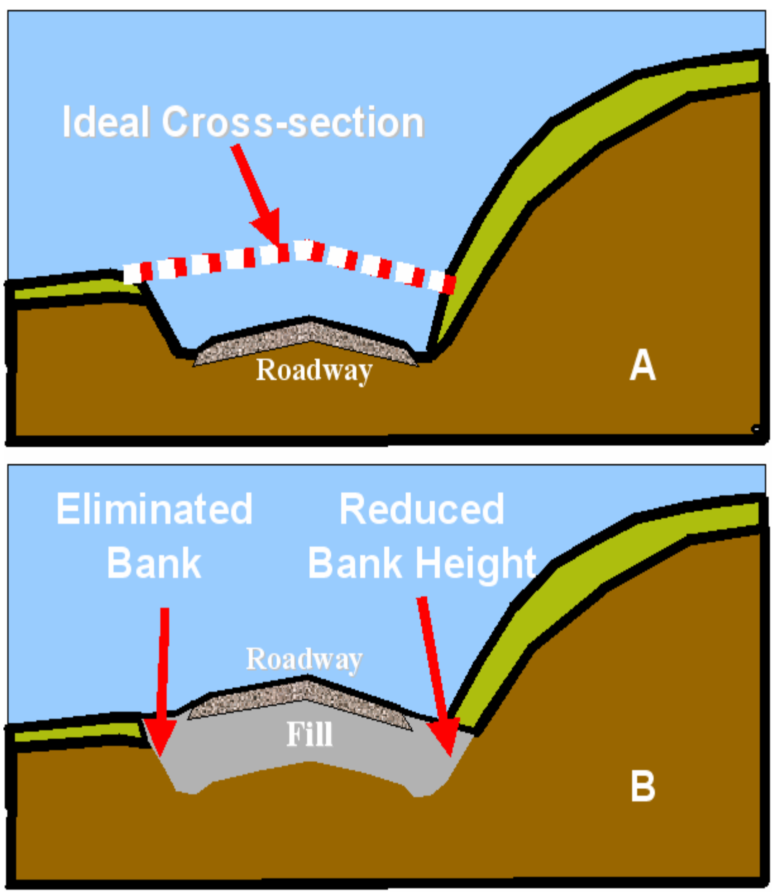


Figure 5-26A shows a typical existing entrenched roadway. Figure 5-26B shows the filled roadway, completely eliminating a bank on one side and reducing the height of the bank on the other side. Depending on terrain, etc, drainage could be sheet-flowed off the road without a ditch on the one side. The road no longer serves as the drainage channel and will experience far less surface erosion, rutting or other degradation. Snow removal no longer becomes a problem since we now have a place to plow it.

Figure 5-26 Raising the Road.

The series of photos shows Red Rose Road in Huntington County, Pennsylvania. The road was raised with free fill shale from a nearby pit. This road then received a final road surface aggregate. (Refer to Appendix 5, Worksites in Focus, to review this Pennsylvania Dirt and Gravel Road Program Project.) Raising the road improves drainage resulting in less erosion and road degradation and thus less road maintenance and a better environment. Winter snows can now be plowed totally off and away from the road, providing better protection from melting snow water seeping back into the road structure.

5-46 Red Rose Road, Huntington County, PA

Before, an entrenched road

During placement of shale fill

After finishing the shale

Final road with driving surface aggregate

Use of Recycled Material. Commonly used fill materials include native rock and mining spoil. Other fill material such as concrete or demolition waste, tire shreds, ground glass, spent sandblasting sand, and coal combustion waste has also been used to aid in recycling programs. Select fill material carefully. Some materials may need special use permits or require special handling. Work closely with your local conservation agencies and state environmental agencies.

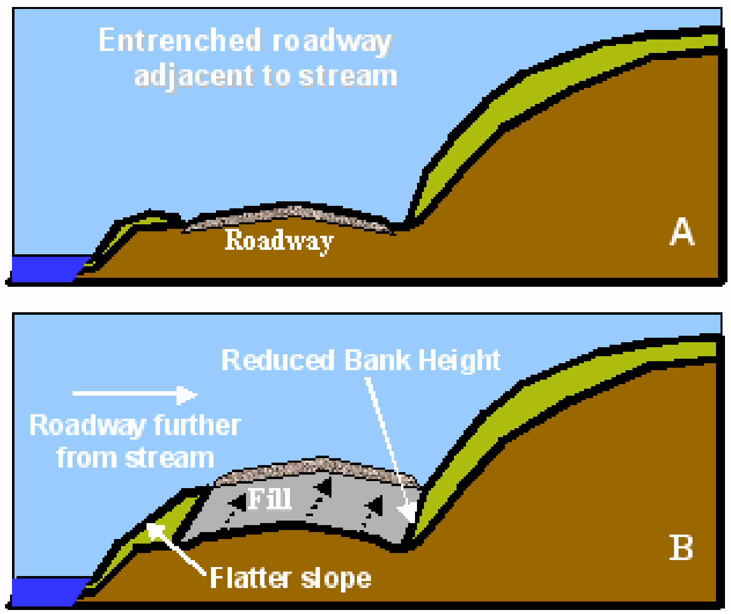


Figure 5-27: Raising the road and moving away from the stream.

5.3.7.2 Raising the Road and Moving Away from a Stream. Figure 5-27 shows a road raising variation where the road has a high embankment on one side and falls steeply off directly to a stream on the other side. The road is entrenched with side ditches. The road is raised upslope away from the stream. We eliminate the entrenchment on the stream side, allowing for sheet flow across additional vegetated area. On the other side, we reduce the embankment height for better stability and drainage control. Depending on the various conditions, insloping could be combined with raising the road, providing additional benefits.

5.3.8 Practices Related to Bridges. Although bridge replacement is neither simple nor inexpensive, sometimes there is simply no alternative. But there are several environmentally sensitive techniques available that will protect the environment and prolong bridge life. Common practice, once more, places the bridge at the low point of the road grade across the stream. The road drains directly onto the bridge, carrying road material and sediment that then drains directly into the stream through the bridge "scuppers" or drainage openings. In addition, abutments built to support the bridge are placed so as to constrict the water flow to the main channel. This scenario poses several maintenance problems. Scour and erosion at bridge abutments shorten bridge life. Further, the constricted water flow frequently results in gravel bars that must be continually removed.

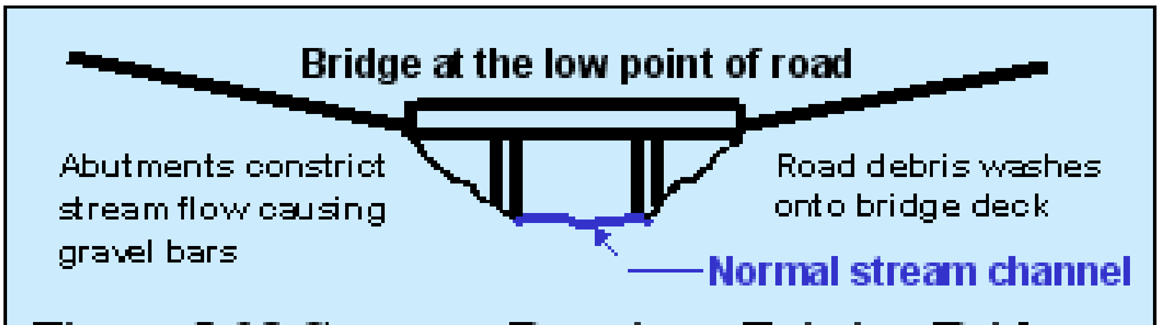
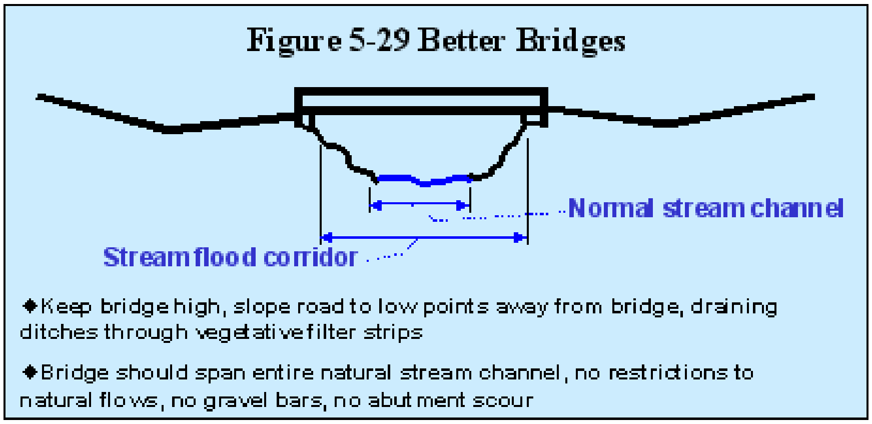


Figure 5-28 Common Practice – Existing Bridges

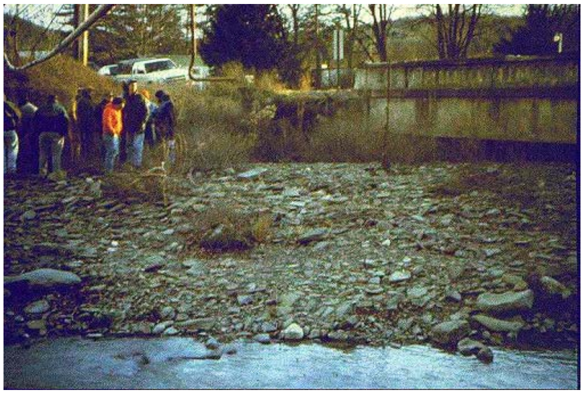
5.3.8.1 The Stream Saver Bridge System. The Stream Saver Bridge System reduces maintenance by raising the bridge and sloping the road away from it. Roadside ditches are then turned out into vegetative filter strips well away from the bridge approaches.



Ideally, the stream saver bridge spans the entire natural stream flood flow channel. Spanning the natural stream corridor reduces interference in stream flows, eliminating abutment scour and gravel bar problems. This system better protects both the environmental stream ecosystem and the bridge structure.

Raising the bridge also allows better drainage off and away from the bridge structure prolonging its life. Bridge drainage can also be carried away from the stream to the same ditch turnout through a vegetative filter strip. Bridge drainage scuppers (openings in the bridge deck – remember the photo from Chapter 3) normally empty the flow directly to the stream along with all the accumulated sediment on the bridge deck. A raised bridge surface that drains off the bridge longitudinally keeps sediment and debris from washing onto the bridge and the bridge surface drainage water clean. This clean water will be much less detrimental to the stream if the bridge has scuppers draining directly into the stream.

5-47 Eliminate this maintenance and environmental problem with Stream Saver Bridges.



5-48 Gravel Bar Removal is a costly maintenance task.

5.3.8.2 Gravel Bar Removal. Gravel bars normally occur because the bridge structure interferes with the natural conditions of stream flow, but can occur naturally anywhere along the stream. At bridge structures, however, gravel bars mean additional maintenance. The bars must be removed to maintain proper flows for flood control and to prevent damage to the bridge.

Sometimes the removed gravel is used for road material. If we refer back to Chapter 3 to the discussion of road material, this "gravel" does not meet the specifications for good road material. It commonly has a rounded shape with little fines and does not lock together to stay in place.

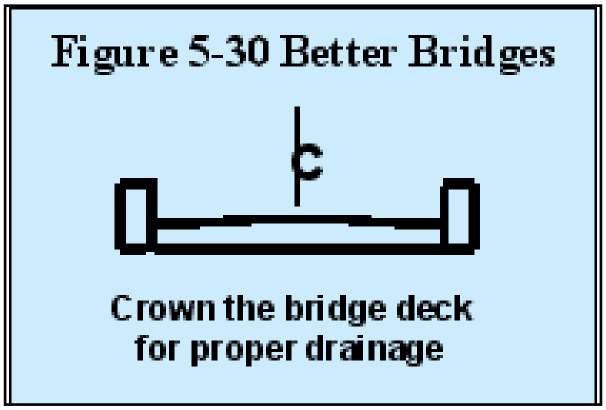
Gravel bar removal also poses several problems other than the cost of removal. Operations cause stream disturbance with resultant turbidity and sediment downstream. This can also result in 100% embeddedness, as described in Chapter 4, to the detriment of stream life. This turbidity and sediment continues for an extended period of time until natural conditions can re-establish the equilibrium.

If gravel bar removal is necessary, there are a few factors to be aware of. Do not use the removed gravel for road material. Keep stream disturbance at a minimum by working in low flow conditions and keeping equipment tires and tracks "dry." Work with your conservation agencies to secure the necessary permits.

5-49 Gravel bar removal causes turbidity and sediment for extended time periods detrimental to the stream ecology. Would you want to fish here?

If gravel bars are extensive and form rapidly after each removal operation, this material has to be coming from somewhere. Look at the stream flow and upstream terrain conditions to determine the source and what may be causing the material deposition, and see if there is a remedy that can prevent future gravel bars from forming.

5.3.8.3 Bridge Decks. Crowning the bridge deck similar to the road will also enhance bridge drainage. Many of our rural bridges have flat decks that aggravate the problem of water and debris on the deck, particularly when the road approaches on either side drain directly to the bridge.



Incorporating these techniques allows for longer bridge life by providing better drainage of the bridge deck and away from the total bridge structure. It also reduces maintenance costs because less material accumulates on the bridge, drainage scuppers are not blocked, less choking sediment flows into the stream, and no gravel bars have to be removed. Just as importantly, the whole stream ecosystem is not affected by these activities, leaving a better environment.

5.4 Summary

This chapter started to fill your toolbox with many various tools or practices that are environmentally sensitive and good for your roads. These practices, for the most part, are simple, practical techniques that can easily be adopted as part of your daily routine maintenance work. Of course, the more major practices of raising the road and replacing bridges can also reap major benefits for your road system and the environment.

Many of these practices, particularly concerning proper drainage, can be adopted for paved roads and will prove to be just as beneficial as they are for unpaved gravel roads.

As you begin to use these practices, you will begin to see the long-range continual benefits for your roads and your environment and thereby for your community.

The following Appendix 5 reviews actual projects in which a combination of practices has been used to solve erosion and sediment pollution problems stemming from dirt and gravel roads.